Vol. 1 No. 2

BIOLOGIA

December, 1955

Published by
THE BIOLOGICAL SOCIETY OF PAKISTAN
Biological Laboratories, Government College,
LAHORE

COMMONWEALTH MYCOLOGICAL INSTITUTE
JUNE
1 MAY 1957

Biologia is published twice a year by The Biological Society of Pakistan, Lahore. The Journal is available in exchange with other Institutions for publications of a similar character.

Annual Subscription : Rs. 15. *Single Copy :* Rs. 8.

EDITORIAL BOARD

SULTAN AHMAD, PH. D.
(Editor-in-Chief)

MUZAFFER AHMAD, PH. D. AHSANUL ISLAM, PH. D.

All communications relating to the supply of the Journal should be addressed to the Treasurer and Business Manager, Mr M. Saleem, M. Sc. (Hons.), Biological Laboratories, Government College, Lahore.

BIOLOGIA

Vol. 1 DECEMBER, 1955 No. 2

Ecological Studies on the Granary Weevil Parasite, *Aplastomorpha calandrae* (Howard) †

M. A. GHANI

Agricultural College and Research Institute, Lyallpur,

and

HARVEY L. SWEETMAN

University of Massachusetts, Amherst, Massachusetts.

The granary weevil parasite, *Aplastomorpha calandrae* (Howard) belongs to the order Hymenoptera, suborder Clistogastra, superfamily Chalcidoidea, and family Pteromalidae. It is an external parasite of grubs and pupae of some of the very serious coleopterous pests of stored products and is a common and important parasite of grain weevils. The discovery of this parasite attacking the cotton stem weevil, *Pempherulus affinis* (Faust), in cotton fields in South India (Krishna Ayyar, 1940) has enhanced the scope of its activities which were previously considered to be limited to pests of stored products. A review of literature showed that with the exception of two papers by Cotton (1923) and Bare (1942) no work of any great value had been done on this parasite. To explore the possibilities of its utilization against two world-wide notorious grain pests, *Sitophilus granarius* (L.) and *S. oryza* (L.), and to find suitable environments for its mass rearing, work on this parasite was initiated.

The bio-ecology of this parasite has been studied for the first time under controlled conditions of temperature and moisture. Its ability to reach the host at various depths in the grain and efficiency in checking weevil infestations have been worked out quantitatively. With the knowledge thus gained it has been possible, to a limited extent, to evaluate its usefulness in biological control work.

† Presented by the senior author as a portion of a Doctoral Thesis at the University of Massachusetts.

REVIEW OF LITERATURE

History and Synonymy

Aplastomorpha calandrae (Howard) was first recorded in 1881 by Comstock from corn infested with *Sitophilus oryza* (L.). In the same year it was bred also from *Sitodrepa panicea* L. The synonymy of this species (Gahan, 1923) is as follows :

Aplastomorpha calandrae (Howard)

Pteromalus calandrae Howard, 1881, *Rept. U.S.D.A.* 1880-1881 : 273.
Meraporus calandrae Ashmead, 1900, in Smith's *Ins. N. J., p.* 558.
Meraporus vandinei Tucker, 1910, *Can. Ent.*, 42 : 343.
Aplastomorpha pratti Crawford, 1913, *Proc. U.S. Nat. Mus.*, 47 : 252.
Neocatolaccus australiensis Girault, 1913, *Mem. Queensl. Mus.*, 2 : 306.
Aplastomorpha australiensis Girault, 1915, *Mem. Queensl. Mus.*, 3 : 313.
Neocatolaccus vandinei Girault, 1917, *Ins. Ins. Mens.*, 5 : 152.
Aplastomorpha vandinei Gahan, 1920, *Proc. Ent. Soc. Wash.*, 22 : 239.

Distribution

A. calandrae has a wide distribution. Its native home is not known. However, it seems quite probable that spread of this parasite has taken place mainly through international commerce in stored products, especially corn, wheat and tobacco, infested with its hosts. The insect is a strong flier (Livingstone & Reed, 1936) and disperses widely (Bare, 1942). The parasite has been recorded in Nyasaland, Greece, Turkey, Russia (Kiev), India, Malaya, Java, Australia, Formosa, Hawaii, British Guiana, Jamaica and the United States (Comstock, 1881 ; Chittenden, 1897, 1899 ; Tucker, 1910 ; Bodkin, 1914, 1915 ; Hill, 1915 ; Vassiliev, 1916 ; Viereck *et al.*, 1916 ; Bridwell, 1917 ; Runner, 1917, 1919 ; Doane, 1919 ; Girault, 1919 ; Hewitt, 1920 ; Cotton, 1920, 1922, 1923 ; Ramakrishna Ayyar, 1921, 1927 ; Timberlake, 1924 ; Gowdy, 1925 ; Back & Cotton, 1926 ; Essing, 1926 ; Okuni, 1928 ; Corbett & Miller, 1933 ; Ramakrishna Ayyar & Margabandu, 1934 ; Isaakides, 1935 ; Reed, 1935 ; Livingstone & Reed, 1936 ; Sweetman, 1936 ; Pruthi, 1937 ; Swezey, 1938 ; Back, 1939 ; Ferriere, 1939 ; Bianchi, 1940 ; Bissell, 1940 ; Krishna Ayyar, 1940 ; Bare, 1942 ; Reed & Vinzant, 1942 ; Smee, 1945).

Hosts

The parasite has a variety of coleopterous hosts that infest stored products.

Anobiidae : *Sitodrepa* sp., *S. panicea* L., *Catorama herbarium* Gorh., *Lasioderma serricorne* F.
Bruchidae : *Bruchus chinensis* L., *B. maculatus* F., *B. phaseoli* Gyll., *B. pruininus* Horn, *Pachymerus* sp.,

Calandridae : *Sitophilus oryza* (L.), *S. granarius* (L.)

Curculionidae : *Caulophilus latinasus* Say, *Pempherulus affinis* (Faust).

Nitidulidae : *Carpophilus obsoletus* Er.

Cotton (1923) reported that Girault (1913) observed this parasite on 'grain moth' as well as miscellaneous forest galls. These observations have not been confirmed. It is recorded that *A. calandrae* which usually parasitizes Coleoptera in stored products, was observed by Krishna Ayyar (1940) in South India attacking stem-boring weevils, *Pempherulus affinis* on *Triumfetta rhomboidea*, *Sida acuta*, and cotton in the fields.

Biology

A. calandrae is a very common ectoparasite of larvae and pupae of some coleopterous insects. Sex attraction is very weak. Copulation takes place just after emergence and lasts for 9 to 35 seconds. Parthenogenetic reproduction occurred, the offspring being males, but the number of eggs laid was reduced to about half that deposited by fertilized females, although the longevity was not affected.

Oviposition started on the first or second day after emergence. Grubs, prepupae and pupae of the host were attacked, although the parasite showed preference for the grub stage. The female moved over the infested grain exploring carefully the surface of the grain with the tips of her antennæ. After locating the host grub, the ovipositor was inserted through the shell of the grain and the host paralyzed. The ovipositor was again inserted and a single egg was deposited on or in close proximity to the host grub. It usually laid one egg on a host, but under confinement and with a limited supply of hosts, attacked the same host more than once. Rarely did more than one parasite develop from a host. The oviposition period continued to about a week before death, the longest and shortest periods being 73 and 39 days. The eggs were laid at the rate of 1 to 12 per day. The number of eggs per female varied from 51 to 283, the average being 170. More eggs were laid in summer than in winter.

The incubation period occupied 1½ to 2 days in summer and 5 days in winter. During summer the larval stage lasted from 3 to 5 days but during winter it was prolonged and varied from 9 to 18 days. The prepupal stage was very short and lasted only a few hours. The pupal stage occupied 6 days in the case of the male, and 7 days in the female during summer, while during winter it was prolonged to as many as 30 days. Under laboratory conditions about 40 per cent of the offspring were females.

The average life of males and females was 47 and 82 days respectively. Those without hosts and food lived for a much shorter time. The parasite, on the average, completed its life cycle in less than half that of its host, *Sitophilus oryza*. The average number of eggs laid by the parasite and the host during summer was 259 and 380, and the percentage of females in the progeny 40 and 60, respectively (Cotton, 1923). It was capable of producing several generations to one of the host (Clausen, 1940).

On *L. serricorne* the egg, as well as larval stage, occupied six days, whereas the pupal stage lasted for about seven days (Runner, 1919). The period of development from egg to adult varied from 10 to 28 days, with an average of 16 days, at 21.7° to 30°C. and 42 to 72 per cent relative humidity. The time from emergence of the first adult until the adults of that generation ceased ovipositing was 115 days ; thus the broods overlapped. The proportion of males was high. The average longevity of males that mated was 32 days, while those which did not, lived for 100 days. The females that mated and oviposited lived for 39 days, while those which did not oviposit lived for 100 days. The adults were not strongly phototropic and often feigned death when disturbed (Bare, 1942).

MATERIAL AND METHODS

Material

The parasite, *Aplastomorpha calandrae* in corn infested with rice weevil, was very kindly supplied by Dr Richard T. Cotton of the U.S. D.A., Bureau of Entomology and Plant Quarantine, from Manhattan, Kansas. The identification of these parasites was later confirmed by Dr C. F. W. Muesebeck of the U. S. National Museum. The cultures of parasites in the laboratory were reared on *Sitophilus granarius* and *S. oryza*.

The granary and rice weevil cultures were maintained in quart Kerr jars and gallon mayonnaise jars. These were about three-fourths filled with wheat or corn and large numbers of weevils liberated in them. Fine meshed wire gauze or paper towel discs were screwed on the top to avoid excessive humidity and to allow aeration. The grain had at least 10% moisture as otherwise weevils would not develop.

Weevil cultures at least three weeks old were employed for starting new parasite cultures and for use in experiments. This was done to insure the presence of all stages of the host.

To reduce the chance of mite infestations, the grain to be used for weevil cultures was either heated directly over a burner and kept at 50° to

60° C. for a few minutes, or poured into boiling water and then dried. A water moat was used to prevent reinfestation with mites.

Methods

The more commonly used method consisted in supplying infested grains in 8-dram glass vials to the parasite for oviposition. Usually about 200 grains from infested cultures were exposed to each female daily. Previous examination showed that at least 20% of the grain had host larvae and pupae of suitable age and size. By this method only total duration of the immature stages and the surviving number of offspring could be studied.

For detailed biological studies No. 5 gelatine capsules, as used by Cotton (1923), were employed. The host larvae and pupae of suitable age and size were used. Oviposition and development of the parasite were observed microscopically through the capsule, without disturbing the host or the developing parasite.

At high humidities the capsules became soft and a little foggy, and gave some trouble at the time of examination. This method was very laborious and time consuming and hence was employed for limited studies only.

Controlled temperature chambers were used in most of the experiments. Two chambers were maintained at 25° and 30° C. with a variation of $\pm 1°$, while the third fluctuated from 19° to 22.5° with an average of 22°. Moisture was controlled with saturated salt solutions with an excess of salt in pint glass-top fruit jars. Three saturation deficiencies (Buxton, 1931) 3, 8, and 15 mm., were used at each temperature.

HABITS AND BEHAVIOUR OF THE ADULT PARASITE

The adults of *A. calandrae* gnaw holes in the grain for emergence. The holes are circular and neatly cut as compared to the exit holes of the grain weevils, and thus can be easily differentiated. The parasites show a weak positive response to light. On escape from cages they fly to the nearest source of light. In search of hosts, however, they moved readily into darkness. They are fairly strong fliers and hence capable of wide dispersal. The parasites are strongly attracted to grain even if free of hosts. Free females in the laboratory were attracted to and sought entrance into infested wheat in jars closed with paper towels.

Movements in Grain

A glass tube 1½ feet long and 3/4 of an inch in diameter was filled to within one inch of the top with uninfested wheat and placed in a vertical

position. Three pairs of parasites were liberated at the top of the grain and the tube closed with a cork. Two minutes after liberation the females had entered the grain column moving through the interspaces. For about half the length of the tube they moved downward inside the grain column, occasionally appearing on the inner sides of the tube, but thereafter more often moved along the tube wall with infrequent excursions into the grain column. After about thirty minutes two females had reached the bottom of the tube, while the males remained in the empty space at the top. The females moved downwards in the uninfested grain, probably in search of hosts, which were not present.

Upward movement of the parasite through uninfested wheat was determined in a heavy paper tube 2½ feet high and 3 inches wide, with a four-inch space at the bottom, covered with wire gauze, 8 meshes to the inch. Uninfested wheat was added to within four inches of the top and the column covered with a petri dish. Seven males and ten females were liberated in the bottom space. One to two females were observed in the top space at intervals from 72 to 124 hours after liberation. One male also reached the top of the column. The column of grain was broken down after eight days into different lengths, sieved, and distribution of dead parasites recorded. One male had reached the top, six were at the bottom. The females were distributed throughout the grain column, two in the bottom space, four at intermediate depths and four at the top.

Apparently the females move in all directions in search of hosts, irrespective of their presence. Evidently the males usually do not follow the females among the grains. The distribution of six pairs in individual glass vials partially filled with wheat was recorded once a day throughout their lives. The females usually remained in the open during the first day after their emergence, apparently for copulation. Thereafter they were inside the grain mass most of the time. Only once was a male observed in the grain mass.

Feeding

Like many other pteromalids, the females of *A. calandrae* fed on the body fluids of their hosts, through 'feeding tubes.' On hosts in capsules the feeding tubes could be seen clearly as threadlike structures connecting the host and the capsule, even for many days after feeding. The adults fed readily on sugar syrup and honey, as well.

Parthenogenesis

The females of *A. calandrae* are known to lay eggs parthenogenetically, the progeny always developing into males (Cotton, 1923). The

offspring of seven unfertilized females were studied. The number of progeny varied from 0 to 78 per female with an average of 37. All of the progeny consisted of males. Under similar environmental conditions fertilized females average 84.4 offspring of both sexes, more than twice that of the unfertilized females. There did not seem to be any difference in the longevity of fertilized and unfertilized females. Similar observations were made by Cotton (1923).

Copulation

Males usually emerge earlier than females and copulation takes place within a few hours after emergence of females. The male may stand in front of the female, face to face, and start courting by caressing her antennae ; or may stand behind and tap her abdomen with his antennae. The female remains comparatively passive whereas the male evinces signs of excitement by quick movements of wings and antennae. After a brief courtship he tries to ride her. The female may remain quiet or move away with the male following her. At the time of copulation the female raises her abdomen a little while the male bends his around that of the female, clinging to her thorax and wings. Copulation was observed in nine cases where it lasted from 2 to 41 seconds with an average of 21. It is however, not certain that transfer of sperms was successful where copulation lasted for 2 or 3 seconds. Frequently two or three males try to ride a female at the same time, though eventually they are shaken off, still clinging to each other. Males may also occasionally be seen riding and clinging to other males.

In order to determine if one mating was enough to fertilize the normal quota of eggs, three unmated females were allowed to mate once. They were then kept with infested grains in jars at 30°C. and fed on honey. Their total progeny consisted of 72, 97, and 88 individuals, out of which 75.0, 60.8, and 75.0%, respectively, were females. Thus one mating is enough for the female to lay the usual number of fertilized eggs. How many times a female mates in her lifetime is unknown.

An attempt was made to determine if one male could fertilize more than one female in the presence of abundant hosts. Batches of 3, 4, and 6 unmated females were given one male per batch. The male was removed after one day from the first, and after two days from the second and third batches. Then the females were separated into jars containing infested grain. Another unmated female was placed with, and allowed to remain with, each male (Table 1). The offspring from 11 of the 13 females exhibited normal percentages of females. Two females in batch II did not reproduce normally, which cannot be attributed to any deficiency on the

part of the male as females should produce numbers of males parthenogenetically. Among the three females offered to the aged males one failed to reproduce appreciably, which cannot be attributed to faulty copulation, while the others produced a relatively low percentage of females. This may have been due to the age of the males, which were two and three days old when given to the females.

It is evident that a male can fertilize several females at least during the first day or two after emergence. This is important in view of the fact that females exceeded the males in the majority of cases.

TABLE 1

Progeny of females sharing one male.

	Batch No. I		Batch No. II		Batch No. III	
	Total	Percentage of females	Total	Percentage of females	Total	Percentage of females
Eggs laid before separation	19	57.9	29	37.9	57	54.4
Female No. 1	54	87.0	1	0	70	47.1
Female No. 2	35	80.0	3	0	65	66.2
Female No. 3	76	71.1	85	80.5	76	73.7
Female No. 4	...	...	89	68.5	71	73.2
Female No. 5	...	...	...	...	60	76.7
Female No. 6	...	...	...	...	76	76.3
Female given old male of the batch	21	47.6	18	27.8	1	0

Oviposition

The female crawls over the infested grains and surveys them with her antennae for suitable host grubs. On locating one she pierces the kernel with her ovipositor and paralyzes the host. After a few thrusts the ovipositor is withdrawn but is soon reinserted and an egg deposited on the host or in the cavity near it. The females prefer grubs more than half grown, prepupae, and early pupae when these were exposed in gelatin capsules. If suitable hosts are scarce young grubs are attacked but the parasites that develop on them are small in size. The parasite larvae first feed on body fluids of the hosts, but later consume tissues as well. If the host grub was too small, the food supply was exhausted and the parasite died. A grub once oviposited upon never regained activity. The parasite larva usually consumed the entire host. While only one parasite per host was observed to develop, up to seven eggs have been

observed on one host. Usually only one egg hatched per host while the surplus shrivelled and died. The first hatched larvae have been seen clinging to unhatched eggs. Whether they damaged or fed on them is not certain. Two freshly hatched larvae on one host were observed in two cases but by the next day one of them had disappeared. However, Cotton (1923) reported two parasites maturing on one host in a few cases. It appeared that laying of more than one egg on one host was superfluous, but this seldom occurred if hosts were plentiful.

In oviposition studies of hosts in grain it was not possible to determine the actual number of eggs laid. An attempt was made to supply more hosts than required by the parasite for this purpose. Therefore, it has been assumed that the parasite laid only one egg per host, and hence the number of offspring developed has been taken as indicative of the number of eggs laid.

Effect of Availability of Hosts on Oviposition : Effect of availability of hosts for oviposition on the number of offspring developed was studied at 30°C. and 3 mm. saturation deficiency, by exposing 100, 200 and 300 grains from an infested culture to some pairs throughout their lives, while a few others were given 100 and 200 grains on alternate days. The same stock culture of hosts was used throughout which had above twenty suitable host grubs and pupae per 100 kernels.

The influence of availability of suitable hosts in grain is obvious (Table 2). The maximum number of parasites emerged when 200 or 300

TABLE 2.

Effect of availability of host on offspring developed at 30°C. and 3 mm. saturation deficiency.

Number of grains exposed	Number of offspring developed per female				
	No. of Pairs	Daily Average	Range		Average
100 daily throughout the life of female	3	...	68	157	101.3
100 and 200 on alternate days) 100) 200	4	11.8 17.4	45	225	108
200 daily throughout the life of female	3	...	111	182	139.3
300 daily throughout the life of female	3	...	113	135	134.0

grains from weevil infested cultures were offered daily. When 100 kernels per day were exposed a marked reduction in parasite offspring

resulted. This fact was further confirmed by pairs receiving 100 and 200 grains on alternate days which, on the average, produced more offspring on the days when 200 grains were exposed.

Oviposition of Undersized Females : There is a great variation in sizes of adults of *A. calandrae* and it is common to find a few small-sized individuals. Oviposition of 8 undersized females with normal-sized males was studied at 30° C. and about 8 mm. saturation deficiency. Seven

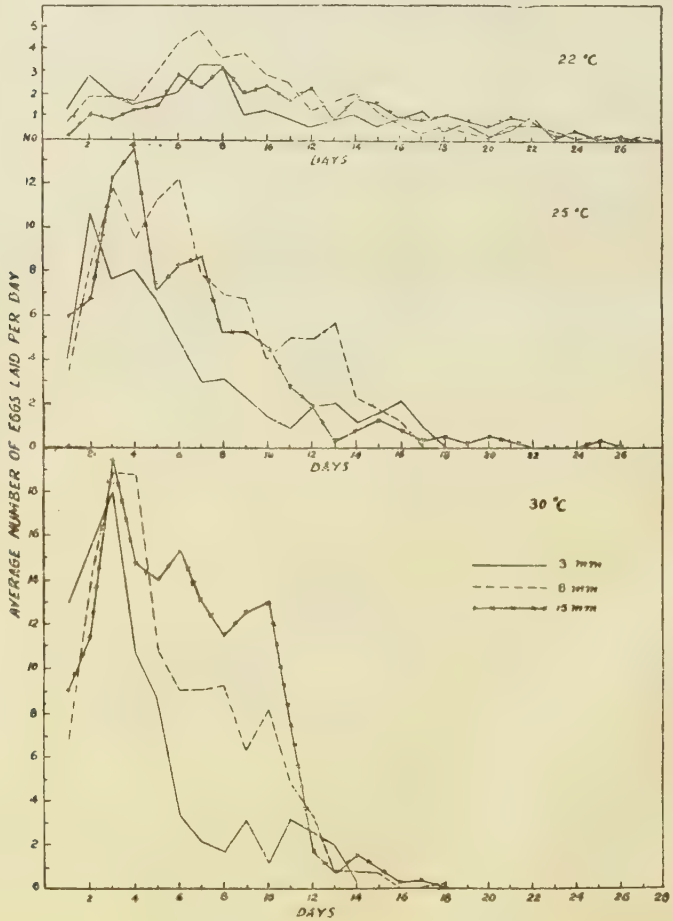


Fig. 1. Average daily rate of oviposition.

females reproduced, a portion of the offspring of each being females. The 8 females produced 200 offspring, 64 males and 136 females, an average of 25 each, all of normal size. Two females produced 40 and 63 young

respectively, the remainder less than 32 each. The average was one-fifth that of normal-sized females. The span of life was much shorter.

Effect on Oviposition of Honey as Food : A few pairs were offered honey or sugar syrup to determine the effect on oviposition. A small piece of absorbent cotton moistened with the food was stuck to the side of the oviposition cage throughout the life of the pair. Sugar syrup did not prove satisfactory, as it dried rapidly at high saturation deficiencies. Eight pairs were offered honey and 12 pairs no additional food. Those offered honey laid about 25% more eggs.

Effect of Temperature and Moisture on Oviposition : Parasites were observed in 3, 8 and 15 mm. saturation deficiencies at 22°, 25°, and 30° C.

Copulation occurs shortly after emergence. The females laid eggs within 1 day at 25° and 30° and in about 1.5 to 2 days at 22°C. Moisture differences had no appreciable effect on preoviposition.

The average daily rate of oviposition of 6 to 8 females based on adult emergence of offspring is presented in Figure 1.

The average rate of oviposition increased with increase in temperature. The peak rates occurred after 7 to 8, 2 to 6, and 3 days at 22°, 25°, and 30° C., respectively. The number of eggs was reduced at 3 mm. in 25° and 30° below other saturation deficits. Low temperature and low saturation deficiency seem to be less favorable for oviposition than other environments tested.

The average number of offspring developed per female increased from low to high temperatures at all the saturation deficiencies (Fig. 2). The moisture of the atmosphere does not seem to have any consistent effect on the number of offspring but that of temperature and moisture operating together is quite evident. The highest average number of offspring

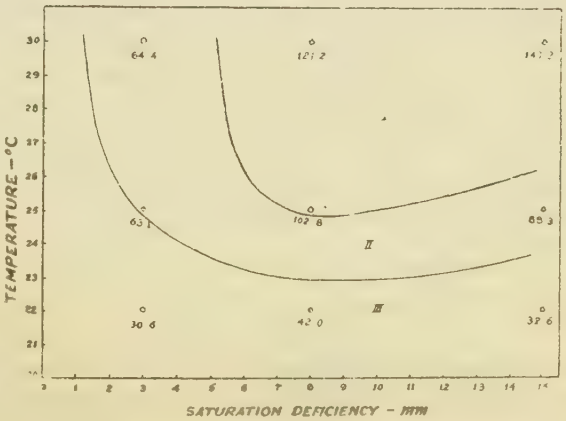


Fig. 2. Number of offspring developed in controlled environments.

was produced in zone I, and the least in zone III.

The maximum number of offspring developed in 24 hours and the maximum during the whole life of any female also showed a similar increase with increase in temperature (Table 3). Moisture, however, did not have any effect on these. The highest number of offspring from any female was 255 at 30° C. and 3 mm. saturation deficiency. Allowing for some mortality during developmental stages and deposition of more than one egg on one host in a few cases, this number probably will not be vastly different from that of Cotton (1923) who recorded the maximum number of eggs deposited as 283.

TABLE. 3

Effect of temperature and moisture on the maximum number of offspring developed in 24 hours and in the lifetime of a female.

Temperature	Saturation deficiency					
	3 mm.	8 mm.	15 mm.	3 mm.	8 mm.	15mm.
	Maximum in 24 hours			Maximum in lifetime		
22° C.	8	10	6	88	75	78
25° C.	23	17	20	120	157	134
30° C.	25	26	32	225	194	316

Temperature and moisture do not seem to have any effect on the proportion of sexes. The females exceeded 50%, varying between 51.6 and 64.7%, except at 22° and 8 mm. and 25° C. and 15 mm. saturation deficiency, where there were 38.8 and 45.5% females. The low percentage of females at 22° and 8 mm. saturation deficiency was probably due to the fact that the progeny of one female consisted of all males, apparently because of unsuccessful fertilization. On the other hand, Cotton (1923) recorded the proportion of females as 40% in the rearing.

The average postoviposition period decreased with an increase in temperature at all the saturation deficiencies. The females survived a day or less at 30°, about 1.5 to 2.5 days at 25° and 3 to 5 days at 22°C. Moisture does not seem to have any appreciable effect on the length of this period.

Longevity

The influence of food and hosts on longevity of adults in various temperatures and moisture conditions was studied by offering them grain containing suitable hosts for oviposition, honey only and neither honey nor hosts. The females usually lived longer than the males. On the whole,

the life of adults fed on honey was long, while those given neither hosts nor honey was very short. The average longevity of both males and females decreased with increase in temperature at all saturation deficiencies. The adults lived longest at 22° C. The maximum life of any male was 47, 55, and 12 days, and that of any female 39, 97, and 13 days, in environments with suitable hosts, honey only, and neither hosts nor honey respectively. Moisture did not have any effect on the longevity of adults that received infested grain suitable for oviposition. On the other hand, the longevity of adults fed on honey was less at 15 mm. than at lower saturation deficiencies although it was considerably prolonged in general over longevity where suitable hosts were available. The length of life of adults with neither hosts nor food was much reduced over that in other environments.

The longevity of adults recorded by Cotton (1923) was greater than observed here. His observations were under room conditions, which may explain the lack of agreement.

DEVELOPMENT OF IMMATURE STAGES

Effect of Food on Development

There was no difference in the average duration from egg to adult emergence of parasites developing on *S. oryza* and *S. granarius* in wheat. The males developed in 9.6 days, the females in 10.7 days.

The average duration of the immature stages on *S. granarius* in corn was slightly longer, 10.1 days for the males and 12.6 days for the females, as compared to wheat as the host food. Grubs, pupae and adults of granary weevils that developed on corn were usually larger than those that developed on wheat. The parasites that developed on these grubs were usually larger. It was also noticed that small host grubs, provided they were not so small as to starve the parasite, tended to hasten their pupation. The parasite larvae pupated as soon as they consumed the host. Presumably the larger size of hosts in corn, because of the available food, explains the lengthened developmental period and increased size.

Effect of Temperature and Moisture on Development

Hosts in Grain : The average duration of the immature stages decreased with increase in temperature, at all saturation deficiencies (Table 4). The average duration of immature stages of males in all environments was shorter than that of females, by less than a day to more than three days, depending upon the temperature. Atmospheric moisture surrounding the kernels did not have any appreciable effect on the parasites that

TABLE 4.

Effect of temperature and moisture on the duration of immature stages (egg to emergence of adults) (average in days).

Temperature	Male		Female		Male		Female		Male		Female	
	Cases	Duration	Cases	Duration	Cases	Duration	Cases	Duration	Cases	Duration	Cases	Duration
						Saturation deficiency						
			3 mm.			8 mm.				15 mm.		
						Host in grain						
22°C.	19	28.6	51	30.6	8	25.9	32	29.5	23	25.1	61	27.8
25°C.	30	13.0	62	14.1	25	12.3	94	13.0	71	15.0	83	16.3
30°C.	19	9.5	64	10.7	18	11.7	42	12.4	96	10.2	99	11.2
						Host in Capsules						
22°C.	4	25.8	4	28.3	7	25.1	2	29.5		*		
25°C.	15	13.4	14	14.9	9	13.6	7	15.1	4	13.0	2	14.0
30°C.	5	10.4	6	11.5	8	10.0	7	11.1	7	10.3	3	11.0

*One individual transformed to an adult.

developed on hosts inside wheat grains. The granary weevil requires at least 10% moisture in grain for its development and after it has started feeding and breeding in the grain, the moisture content increases by 5 to 6% (Gay & Ratcliffe, 1941). By the time the hosts have developed sufficiently for parasite development the moisture content of the grain has increased. Usually the parasite completes its development before the moisture content can be altered sufficiently by atmospheric conditions to have any appreciable effect on the parasite.

The variations in the moisture content of the grain were studied by exposing the uninfested wheat grains in the various environments for lengths of time, up to a maximum of the life cycle of the

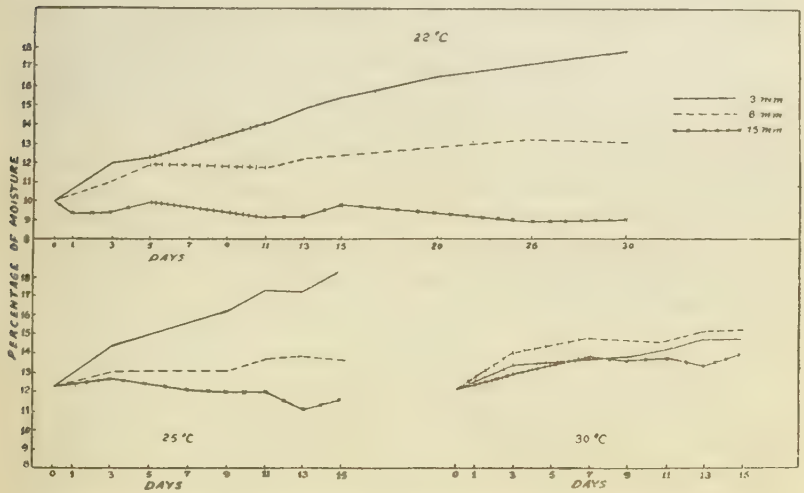


Fig. 3. Changes in moisture content of wheat grains in controlled conditions.

parasite at that temperature. The percentage of moisture was determined on dry weight basis after drying the grain in an oven at 100° C. for 48 hours (Figure 3). The moisture in the grain at 22° C. increased 8% at 3 mm.; 3.3% at 8 mm.; and decreased 1% at 15 mm. in about 30 days. Similarly at 25° C. it increased 6.3% at 3 mm.; 1.5% at 8 mm., and decreased 0.7% at 15 mm. in about 15 days. At 30° C it showed an increase at all saturation deficits, being 2.6, 3 and 1.8% at 3, 8, and 15 mm., respectively, in 15 days. This, however, will not represent the exact nature and extent of changes in the moisture content of the infested grain where another disturbing factor, the host, is present. Attempts to correlate these moisture changes with the developmental period of the parasite failed

to show any relationship. The food of the parasite consists of host fluids and tissues rich in moisture and probably all of its water requirements are thus met.

Host in Gelatine Capsules : Hosts were offered to the parasites in gelatine capsules in order to observe parasite development. The developmental period was similar to that in grain (Table 4). The response to temperature and moisture was also similar.

Females offered suitable hosts in capsules laid very few eggs and parasitization was low. At 25° and 30° C. and 3 mm. saturation deficit about 19% as many eggs were laid and at 8 and 15 mm. from 5 to 9% as many eggs as on grain. Total parasitization varied from 15 to 28% with a considerably higher percentage of eggs deposited on grubs than on pupae. The length of life of the females was reduced over those on grain also.

The average duration of eggs, larval, prepupal and pupal stages of individuals that matured is given in Table 5. The effect of temperature on the immature stages is obvious. All the stages were shortened with an increase in temperature. Atmospheric moisture failed to show any significant effect on the duration of the immature stages. The duration of the larval and pupal stages of males was shorter than that of females at all temperatures, the difference being more pronounced in the pupal stage. No difference in the prepupal stages of the two sexes was observed. The pupal stage always lasted for a longer period than the larval stage.

ABILITY OF *A. calandrae* TO REACH THE HOST IN GRAIN

Capacity to discover or locate hosts is one of the important factors to be considered in the utilization of a parasite for biological control (Sweetman, 1936). This factor assumes even greater importance when the host is scarce or difficult to reach. *A. calandrae* is a strong flier and is capable of dispersal for considerable distance. Since the bulk of grain is stored in quantities of 1000 bushels or more, by private and governmental agencies, the depth to which the parasites will disperse and penetrate in search of hosts is important.

Penetration of the parasite into masses of grain was studied by attaching quart ice-cream cartons, 6¾ inches long and 3½ inches in diameter, with tops and bottoms removed except the bottom of the lowermost carton, end to end to a desired length by means of gummed paper. The bottom was filled to a depth of 3 to 4 inches with infested grain, then uninfested grain added to within 6 inches of the top of the column. Fifteen pairs of parasites were liberated in the top cavity and a tightly-fitting petri dish with a small piece of absorbent cotton dipped in honey inverted

TABLE 5.

Effect of temperature and moisture on the duration of various immature stages.

Temperature	Saturation Deficiency (mm.)	Average Duration in Days						
		Egg	Male			Female		
			Larval	Prepupal	Pupal	Larval	Prepupal	Pupal
22°C.	3	2.1	9.0	1.0	13.8	9.3	1.3	15.5
	8	2.1	9.0	1.6	12.6	9.0	...	...
	15	2.0	9 0	1.0	14.0	...	...	...
25°C.	3	1.1	4.0	1.0	7.4	4.6	1.0	8.3
	8	1.0	4.5	1.0	7.1	5.2	1.0	7.9
	15	1.0	4.5	1.0	6.5	4.5	1.0	7.5
30°C.	3	<1.0	3.3	<1.0	5.4	3.6	<1.0	6.2
	8	<1.0	3.3	<1.0	5.1	3.8	<1.0	6.0
	15	<1.0	3.0	<1.0	5.6	3.6	<1.0	6.0

over the top. The columns of grain were examined after about fifteen days. The originally infested and uninfested grains were divided into sections and sieved for dead and living parasites. The infested grain was then kept in the laboratory and watched for parasites. The presence of parasites in or emerging from the infested grain was used as a measure of successful penetration of the parasites. In wheat the parasite reached the host at a depth of six feet but failed twice to do so at seven feet. On the other hand, the parasite could penetrate through corn to a much greater depth. The maximum column of corn tested in these experiments was ten feet long, which the parasite penetrated successfully. The differences in the depth reached in search of hosts through columns of wheat and of corn were due evidently to differences in size and shape of wheat and corn grains. Corn kernels being larger and more irregular in shape, as compared to wheat kernels, probably had larger interspaces and thus enabled the parasite to crawl through them to greater depths in search of hosts. It seems reasonable to assume that the amount and size of interspaces in the lower layers of grain will decrease with an increase in height of grain column.

The males liberated along with females usually died in the top layers of the grain columns. No dead males were recovered below the first foot in wheat and 3½ feet in corn.

The capacity of the parasite to reach the host in big wheat storage bins seems to be extremely limited and consequently its ability to control grain weevils under these conditions is very doubtful; whereas in the case of corn it might penetrate to greater depths and give better results.

EFFICIENCY OF THE PARASITE IN CHECKING WEEVIL INFESTATIONS

Four sets of granary weevil cultures, each of which consisted of 7 jars, were raised in the laboratory in quart kerr jars containing 500 grams of wheat. Twenty adult weevils were introduced in two sets and 40 in the others. About one month after starting of the cultures 1, 2, 3, 4, 5, and 6 parasite females with excess of males were liberated in six cultures and the seventh kept as a check, in each set. After nearly a month samples of 200 grains were taken fortnightly from the middle of the culture with a glass tube about 1/2 inch in diameter. The adult weevils and parasites in these samples were returned to the culture. The samples were kept in the laboratory and the parasites that emerged during the first 15 days and weevils in one month's time were recorded. Observations were continued for four months, at which time the grain was almost entirely destroyed by the weevils. The results are presented in Figures 4 and 5.

Both the host and the parasite populations were low at the beginning of the experiment. The weevil population increased rapidly while the parasite generally lagged behind by 15 to 30 days. This lag of the parasites behind the host population may be associated with the inability of the parasite to reach or locate hosts. The number of parasites exceeded that of the host during the fourth month, perhaps because of shortage of food for the host.

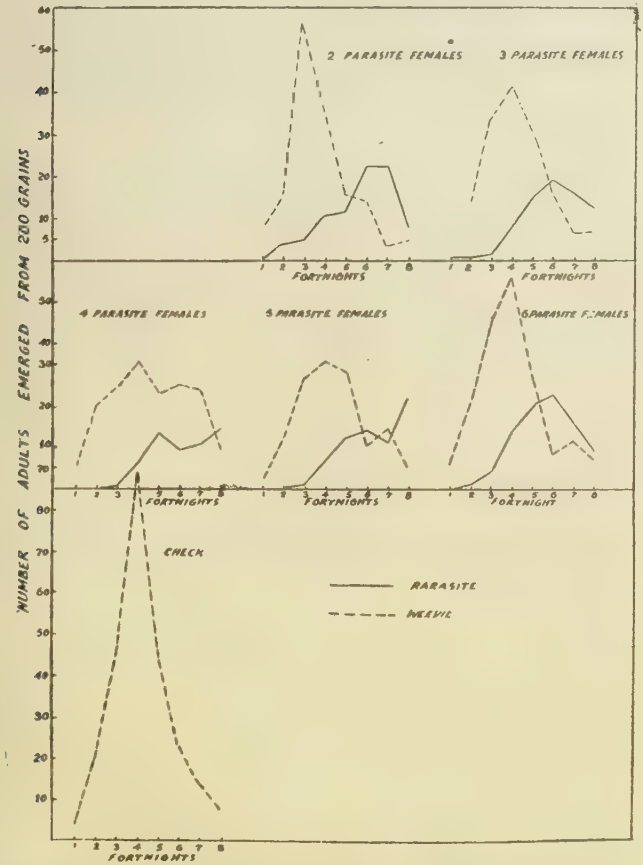


Fig. 4. Parasite and weevil population in cultures with 20 original weevils.

The initial number of parasite females liberated did not have any consistent or marked effect on the parasite or weevil population. Probably the number of suitable hosts accessible to the parasite was the limiting

factor. Where one female was introduced in cultures with 20 original weevils, parasitization was unsuccessful in two tests. The total reduction in weevil population with various numbers of parasite females in 4 months' time varied from 27 to 45% in the sets with 20 original weevils (Figure 4) and 34 to 59% in the case of 40 original weevils (Figure 5). It was, thus higher in the latter case, probably because of the larger number of suitable hosts available for parasitization. The maximum reduction occurred in cultures starting with 5 parasite females.

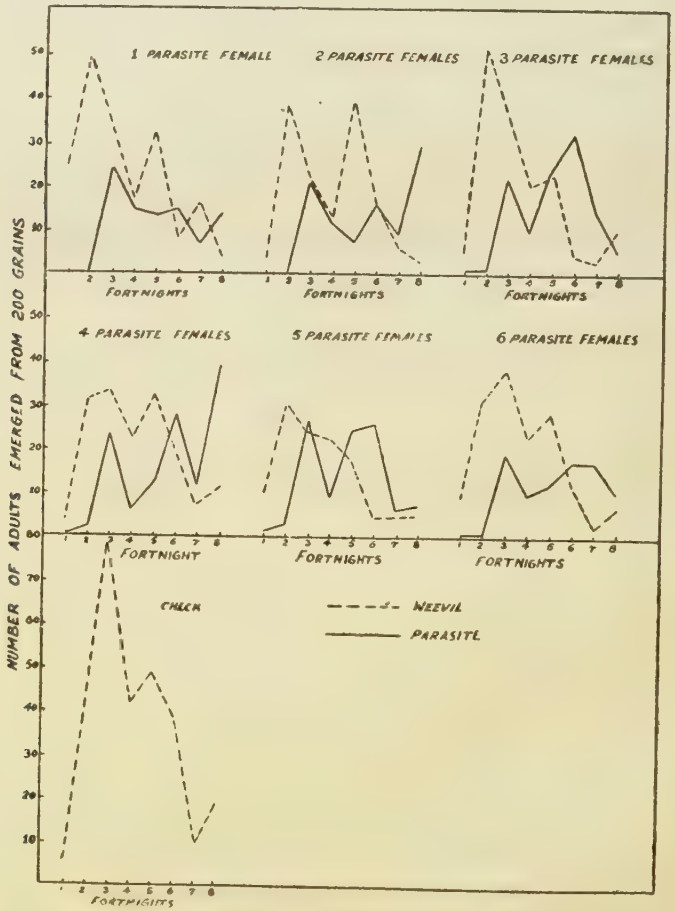


Fig. 5. Parasite and weevil population in cultures with 40 original weevils.

Though the weevil population of cultures with parasites was lower than the check, it showed a similar trend. The peaks of weevil population

were reached about 1½ to 2 months after liberation of the parasites in the cultures with 20, and 1 to 1½ months in cultures with 40 original weevils.

The parasite under the conditions tested failed to successfully control the granary weevil but perhaps delayed destruction of the grain. This was probably due to the inability of the parasite to build up its numbers rapidly, presumably because of its incapacity to reach or locate a majority of hosts in the grain. The host larvae and pupae that escaped attack by the parasite were able to produce damage and to reproduce which contributed towards the rapid destruction of the grain. These conclusions agree, in general, with those of previous workers (Cotton, 1923; Back, 1939; Livingstone & Reed, 1936; Reed & Vinzant, 1942).

SUMMARY AND CONCLUSIONS

Aplastomorpha calandrae (How.) is a widely distributed ectoparasite of larvae and pupae of some of the destructive pests of stored products, especially the grain weevils. It is known to attack fourteen species of insects that belong to five different families of Coleoptera.

The adults showed a weak positive response to light when they escaped from cages and are capable of wide dispersal through flight. They were attracted to grain and females moved readily into darkness in grain in all directions in search of hosts, even in uninfested grain. The females constructed tubes for feeding on the body fluids of the host grubs.

Parthenogenesis occurred with progeny consisting of males only. Copulation, which lasted for a few seconds, took place within a few hours after emergence. A single mating was adequate for normal fertilization and a male could fertilize more than one female. This is important in view of the fact that females in the progeny usually exceeded 50%. The parasite preferred grubs more than half-grown as hosts but attacked prepupae and early pupae also. Normally only one parasite developed on a host, and therefore, laying of more than one egg on a host was superfluous, but this occurred if the hosts were scarce. Thus the availability of hosts within certain limits affected the number of parasites. There was much variation in the size of adults dependent upon the amount of food available to the larvae. The number of offspring developed from undersized females was about one-fifth that of normal females, though there was no difference in the proportion of sexes. The parasites that fed on honey lived longer and laid more eggs than those offered host material only.

The influence of temperature and moisture on reproduction was well marked. The pre- and postoviposition periods decreased with an increase

in temperature but seemed independent of atmospheric moisture. Presumably they secured adequate moisture from the host fluids which they fed on. Peak oviposition occurred from 25° to 30° C. and 8 to 15 mm. saturation deficiency of atmospheric moisture outside the grain mass.

The maximum number of offspring developed at atmospheric moisture of 8 and 15 mm. at 25° and 15 mm. saturation deficit at 30° C. The greatest number of progeny by a female was 225. Over 50% of the progeny from fertilized females were of that sex. The progeny of unfertilized females were all males and the total less than half that of fertilized females.

The parasites developed and emerged in 10 to 12 days at 30° but development was prolonged to 28 to 30 days at 22° C. The males matured in about a day less than the females. Atmospheric moisture had little effect on development except in dry conditions at 22°. The female larvae spent about 3.5 to 4 days in the larval stage, less than a day in the prepupal stage and about 6 days as pupa at 30°.

The female parasites in search of hosts penetrated through columns of corn to a depth of ten feet and to six feet in wheat, but failed to do so through seven feet of wheat. Males entered the grain mass to a very limited extent only.

The parasite failed to control the granary weevil and protect the grain from destruction in quart Kerr jars in the laboratory. With present knowledge the parasite does not appear capable of controlling the granary weevil.

LITERATURE CITED

Back, E. A., 1939. The cigarette beetle as a pest of cottonseed meal. J. Econ. Ent., **32** : 747.

Back, E. A., & Cotton, R. T., 1926. The granary weevil. U.S.D.A. Dept. Bull., 1393 : 1-35.

Bare, C. O., 1942. Some natural enemies of stored tobacco insects with biological notes. J. Econ. Ent., **35** : 185.

Bianchi, F. A., 1940. Notes on the role of self introduced insects in the economic entomology of Hawaii. Proc. Hawiian Ent. Soc., **10** : 382.

Bissell, T. L., 1940. Curculionidae, Bruchidae, Lepidoptera and their parasites infesting the seed pods of cowpea and various wild plants. J. Econ. Ent., **33** : 846.

Bodkin, G. E., 1914. Parasite determinations. J. Bd. Agr. Brit. Guiana, **7** (4) : 200. (Cited from abstract in R.A.E. (A) **2** : 520).

———, 1915. Report of the economic biologist. Rept. Dept. Sci. Agr. Brit. Guiana, 1914-15 : 1-11. (Cited from abstract in R.A.E. (A) **4** : 360).

Bridwell, J. C., 1917. Notes on the Bruchidae and their parasites in the Hawaiian Islands. Proc. Hawaiian Ent. Soc., **3** : 488.

Buxton, P. A., 1931. The measurement and control of atmospheric humidity in relation to entomological problems. Bull. Ent. Res., **22** : 431-47.

Chittenden, F. H., 1897. Some little known insects affecting stored vegetable products. U.S.D.A. Div. of Ent. Bull., **8** (NS) : 43-45.

———, 1899. Insects injurious to beans and peas. U.S.D.A. Year Book (1898), pp. 245-247.

Clausen, C. P., 1940. *Entomophagous insects.* New York.

Comstock, J. H., 1881. Report of the entomologist. U.S.D.A. Rept. (1880), p. 273.

Corbett, G. H., & Miller, N. C. E., 1933. A list of insects with their parasites and predators in Malaya. Sci. Ser. Dept. Agr. S. S. and F. M. S., **13** : 1-15. (Cited from abstract in R. A. E. (A) **21** : 676.

Cotton, R. T., 1920. Rice weevil (*Calandra*) *Sitophilus oryza*. J. Agr. Res., **20** : 421-422.

———, 1922. Broad-nosed grain weevil. U. S. D. A. Bull., 1085 : 1-10.

———, 1923. *Aplastomorpha vandinei* Tucker, an important parasite of *Sitophilus oryza* L. J. Agr. Res., **23** : 549-556.

Doane, R. W., 1919. Weevils in Australian wheat in California. Econ. Ent., **12** : 312.

Essing, E. O., 1926. *Insects of western North America.* New York.

Ferriere, C., 1939. Chalcid flies attacking noxious beetles in India and New Guinea. Bull. Ent. Res., **30** : 165-166.

Gahan, A. B., 1923. Types of two Chalcid-flies misidentified. Proc. Ent. Soc. Wash., **25** : 185-188.

Gay, F. J., & Ratcliffe, F. N., 1941. The importance of *Rhizopertha dominica* as a pest of wheat under wartime storage conditions. J. Coun. Sci. Industr. Res. Aust., **14** (3) : 173-180. (Cited from abstract in R. A. E. (A) **30** : 278-279).

Girault, A. A., 1913. Australian Hymenoptera Chalcidoidea. VI. Mem. Queensland Mus., **5** : 303-334.

———, 1919. Javanese Chalcid flies. Treubia Batavia, **5** (2) : 53-59 (Cited from abstract in R. A. E. (A) **7** : 536).

Gowdey, C. C., 1925. Report of government entomologist of Jamaica. Ann. Rept. Dept. Sci. and Agri. (1924), pp. 17-20.

Hewitt, C. G., 1920. Report of the Dominion entomologist and consulting zoologist. Dept. Agr. Canada (1917-1918), p. 16.

Hill, G. F., 1915. Insect pests of plants : northern territory of Australia. Dept. Extern. Affairs Melbourne. Bull. N. Territ., **13** : 1-16. (Cited from abstract in R. A. E. (A) **4** : 110-111).

Isaakides, C. A., 1935. Des insectes at autres animaux nuisibles aux plantes cultivees et des insectes auxiliaires de la Grece. Ann. Inst. Phytopath. Benaki. **1**, Fasc. 2 : 1-12. (Cited from abstract in R. A. E. (A) **24** : 611).

Krishna Ayyar, P. N., 1940. The alternate host plants and associated parasites of *Pempheres offinis* Fuast in South India. Indian J. Ent., **2** : 213-227.

Livingstone, E. M. & Reed, W. D., 1936. Insect fauna of cured tobacco in storage in the United States. J. Econ. Ent. **29** : 1020.

Okuni, T., 1928. Report of the studies on stored grain pests. Part II. Rept. Govt. Res. Inst. Dept. Agr. Formosa, **34** : 1-121. (Cited from abstract in R. A. E. (A) **17** : 110).

Pruthi, H. S., 1937. Report of the Imperial entomologist. Sci. Rept. Agr. Res. Inst. New Delhi (1935-36), pp. 123-137. (Cited from abstract in R. A. E. (A) **25** : 30).

Ramakrishna Ayyar, T. V., 1921. A list of parasitic Hymenoptera of economic importance from South India. Rept. Proc. 4th Ent. Meeting Pusa, pp. 363-366.

———, 1927. The parasitic Hymenoptera noted from South India. Bull. Ent. Res., **18** : 77.

Ramakrishna Ayyar, T. V. & Margabandu, V., 1934. Hymenopterous parasites of economic importance in South India. Madras Agr. J., **22** : 430-446.

Reed, W. D., 1935. Notes on the distribution of cured tobacco insects in the Near East. Proc. Ent. Soc. Wash., **37** : 42-48.

Reed, W. D. & Vinzant, J. P., 1942. Control of insects attacking stored tobacco and tobacco products. U. S. D. A. Circ. 635, p. 12.

Runner, G. A., 1917. The tobacco beetle and how to prevent damage by it. U. S. D. A. Farmers' Bull. 846, p. 13.

———, 1919. The tobacco beetle. An important pest in tobacco products. U. S. D. A. Bull. 737, pp. 35-36.

Smee, C., 1945. Report of the entomologist, 1944. Zamba Dept. Agr. Nyasaland, pp. 1-5. (Typescript). (Cited from abstract in R. A. E. (A) **34** : 63).

Sweetman, H. L., 1936. *The biological control of insects, with a chapter on weed control.* Ithaca, New York.

Swezey, O. H., 1938. Notes and exhibits. Proc. Hawaiian Ent. Soc.,**10** : 21.

Timberlake, P. H., 1924. Records of the introduced and immigrant Chalcid flies of the Hawaiian Islands (Hymenoptera). Proc. Hawaiian Ent. Soc., **5** : 422.

Tucker, E. S., 1910. New parasites of the genus *Meraporus*. Canadian Ent., **42** : 343-344.

Vassiliev, E. M., 1916. The position of the question of the parasites of *Calandra granaria* L. (Husbandry), Kiev 11 (1-2) : 20-23. (Cited from abstract in R. A. E. (A) **4** : 143).

Viereck, H. L., MacGillivray A. D., Brues, C. T., Wheeler, W. M. & Rohwer, S. A., 1916. *Guide to the insects of Connecticut.* Part III *The Hymenoptera or wasp-like insects of Connecticut.*

Thecaphora atterima Tulasne, a new record for West Pakistan

SULTAN AHMAD

Department of Botany, Government College, Lahore.

Recently the author received from Quetta a species of *Carex* (Cyperaceae) which was found to be smutted. On closer examination the smut proved to be a species of the genus *Thecaphora* which is characterized by the possession of fairly permanent reddish brown spore balls composed of elongated or wedge-shaped spores. The various species belonging to this genus are distributed widely in Europe and North America, attacking members of the families Leguminoseae, Convolvulaceae, Compositae, Gramineae and Cyperaceae.

Out of the fifteen known species of *Thecaphora*, only two attack members of the family Cyperaceae, and the present smut is identical with *T. atterima* Tul. This species is known only from Europe, North America and Central Asia.

This smut is not rare and probably occurs in Afghanistan and Iran as well. It generally escapes notice as the sori are quite inconspicuous being concealed between closely overlapping bracts. It is hoped that the botanists residing in the mountainous districts of West Pakistan will make a more thorough search for this interesting species.

The following brief description is added to facilitate its identification:

Thecaphora atterima Tulasne in *Ann. Sci. Nat.* III. 7 : 110, 1847.

Sori indefinite, occurring at the inner base of the bracts of the staminate spikes and appearing as a black granular spore mass when the bracts are removed. Spore balls sub-globose ovate or oblong, opaque, dark olivaceous brown, 27-57 × 19-48 μ Spores globose to polyhedral, reddish brown, 9-16 μ in diameter, the wall forming the exterior of the spore ball thick and verrucose.

The Skull of *Uromastix hardwickii* Gray

AHSANUL ISLAM

Department of Zoology, Government College, Lahore.

INTRODUCTION

The skull of *Uromastix* has attracted considerable attention in the past, largely because it retains a number of primitive features which are reminiscent of the developing skull of *Sphenodon*. However most of the studies have dealt either with one particular aspect, or are based on a superficial examination of a few dried skulls. Busch (1898), for example, has dealt with the palate and the suspensorium. More recently, Saksena (1942) has re-examined the palate of three species of *Uromastix*, and El-Toubi (1945) has made a few miscellaneous observations on the skull of *U. aegyptia*. Figures of the complete skull are given in the text-book by Sedgwick (1905), but the accompanying account pertains to a generalized lacertilian skull.

In the present paper an attempt has been made to describe the complete skull in some detail. Wherever possible, comparisons have been made with the skulls of *Varanus*, *Calotes*, *Lacerta*, *Hemidactylus*, and other lizards.

I am thankful to my friends M. Aslam Khan and S. Mohsin Raza for their help in the preparation of the figures.

GENERAL CHARACTERISTICS

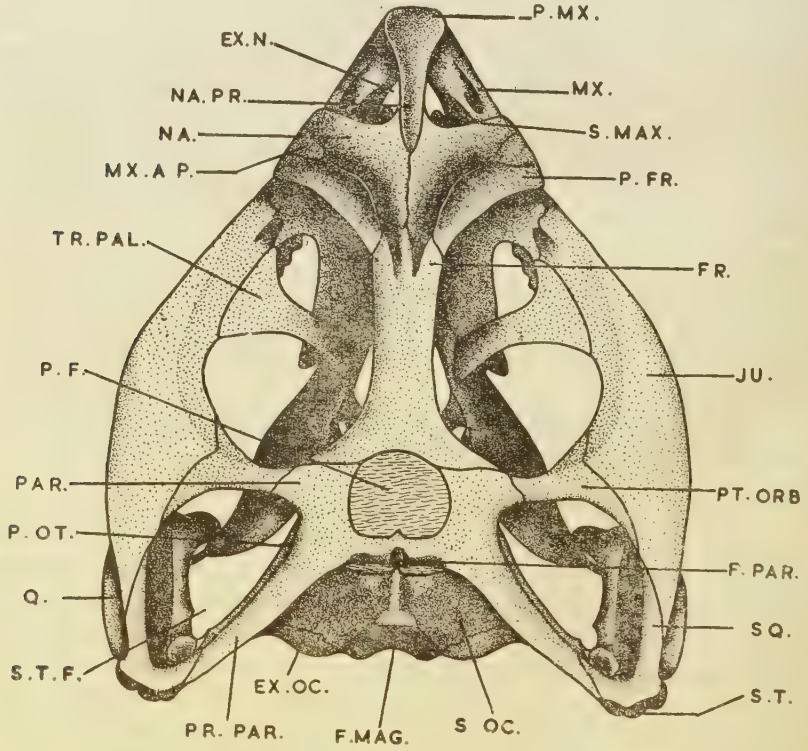
The skull of *Uromastix hardwickii* Gray is roughly pyramidal in shape : the posterior end of the skull representing the base of the pyramid, and the anterior end its apex. When viewed from the dorsal or the ventral side, it is triangular in outline, but its lateral and posterior sides are more or less rectangular. The orbits are very large, their length being just about one-half the total length of the skull from the premaxilla to the posterior border of the occipital condyle. The lower jaw is a stout structure and its two rami are firmly united through a bony symphysis at a tuberosity on the mesial side of each ramus.

The skull is very compactly built and is well-ossified, although several parts, such as the interorbital septum, the nasal septum, the antero-ventral wall of the cranium and the olfactory capsules are, for the

greater part, cartilaginous even in the adult. As in *Varanus* (Bahl, 1937), *Calotes* (Iyer, 1943), and most other lizards, the sutures between most bones persist throughout life.

THE CRANIUM

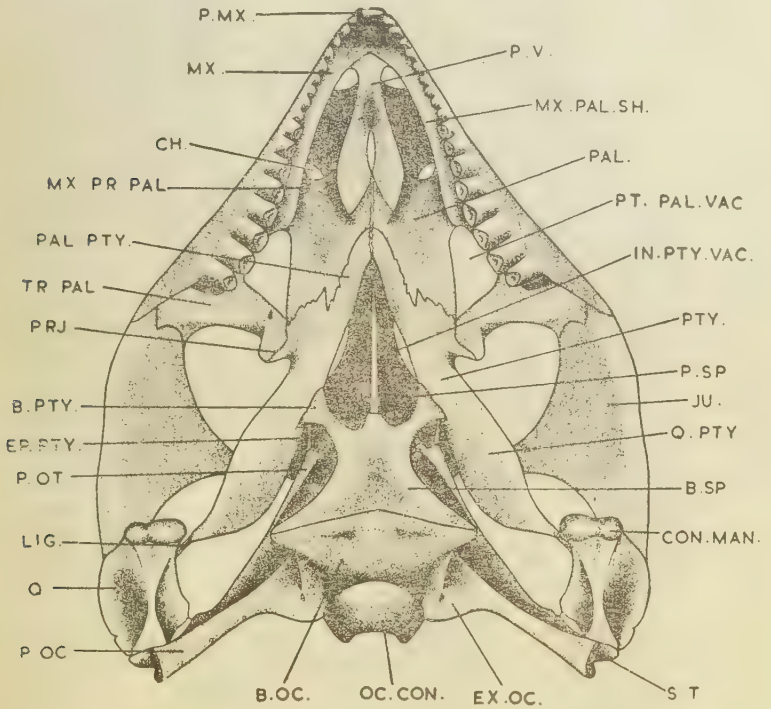
The cranium or brain-box constitutes the axial part of the posterior half of the skull. It is disposed obliquely, being higher in front and lower behind. On the ventral side the cranium is almost completely ossified up to the infundibulum, while on the dorsal side the ossification is complete up to a little in front of the optic lobes. In the region of the cerebral hemispheres there is a very large hole, the parietal fossa, in the roof of



Dorsal view of the skull.

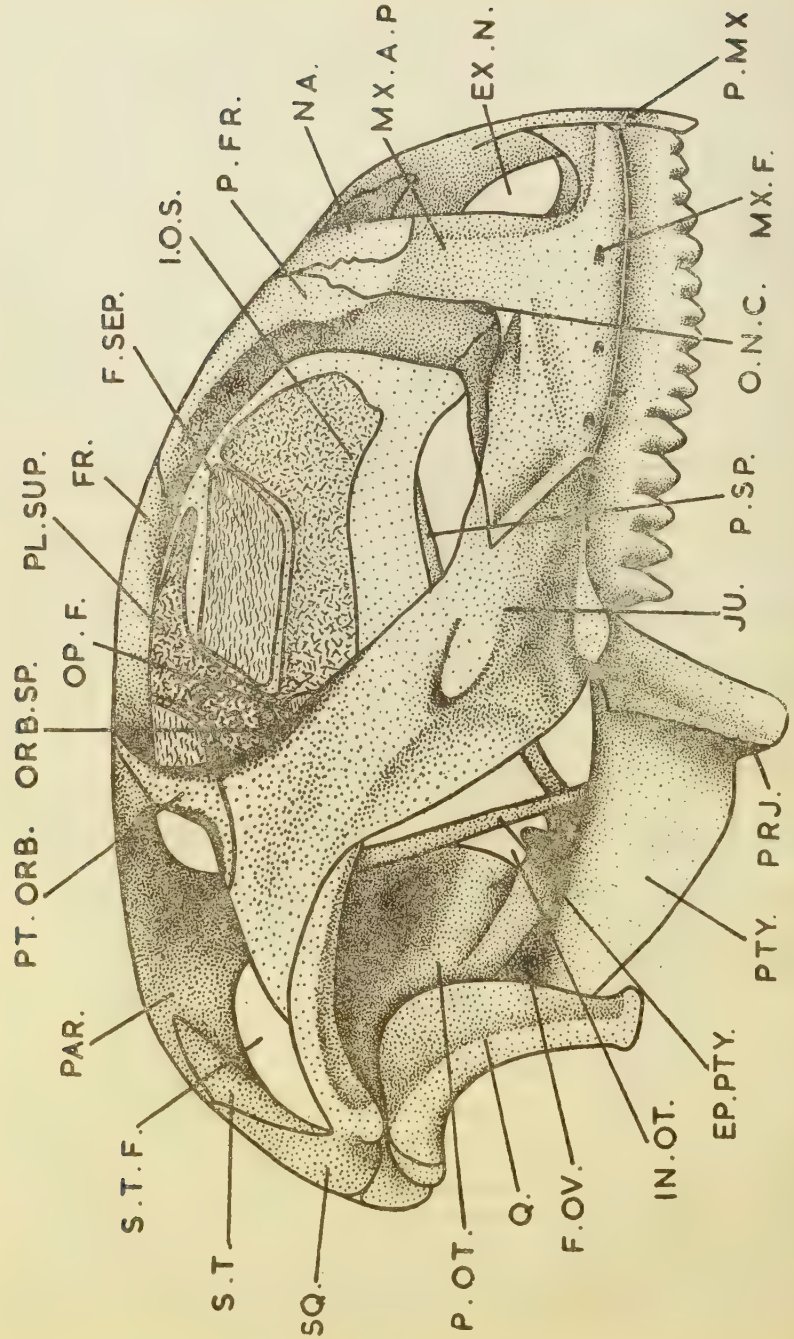
EX. N., external nostril; *EX. OC.*, exoccipital; *F. MAG.*, foramen magnum; *F. PAR*, fossa parietalis; *FR.*, frontal; *JU.*, jugal; *MX.*, maxilla; *MX. A. P.*, ascending process of maxilla; *NA.*, nasal; *NA. PR.*, nasal process of premaxilla; *PAR.*, parietal; *P. F.*, pineal fossa; *P. FR.*, prefrontal; *P. MX.*, premaxilla; *P. OT.*, pro-otic; *PR. PAR.*, processus parietalis; *PT. ORB.*, postorbital; *Q.*, quadrate; *S. OC.*, supra-occipital; *S. MAX.*, septomaxillary; *SQ.*, squamosal; *S. T.*, supratemporal; *S. T. F.*, supratemporal fossa; *TR. PAL.*, transpalatine. [x 4].

the cranium. This fossa is covered over by a tough fibrous membrane which is perforated by a small aperture, the pineal foramen. In front and on either side of the parietal fossa the roof of the cranium is well-ossified. On the lateral sides only the posterior half, up to the posterior border of the optic lobes, is ossified. Thus, the greater part of the sides and the floor of the cranium are unossified, remaining partly membranous and partly cartilaginous.



Ventral view of the skull.

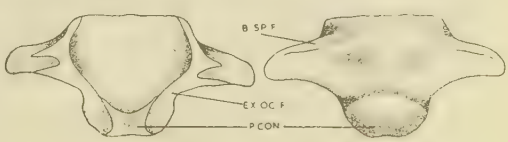
B. OC., basioccipital; *B. SP.*, basisphenoid; *B. PTY.*, basipterygoid process; *CH.*, choana; *CON. MAN.*, condylus mandibularis; *EP. PTY.*, epipterygoid; *EX. OC.*, exoccipital; *IN. PTY. VAC.*, interpterygoid vacuity; *JU.*, jugal; *LIG.*, ligament; *MX.*, maxilla; *MX., PAL. SH.*, maxillo-palatine shelf; *MX. PR., PAL.*, maxillary process of palatine; *OC. CON.*, occipital condyle; *PAL.*, palatine; *PAL. PTY.*, palatal part of pterygoid; *P. MX.*, premaxilla; *P. OC.*, paroccipital process; *P. OT.*, pro-otic; *PRJ.*, pterygo-transpalatine projection; *P. SP.*, parasphenoid; *PT. PAL. VAC.*, posterior palatine vacuity; *PTY.*, pterygoid; *P.V.*, prevomer; *Q.*, quadrate; *Q. PTY.*, quadrate process of pterygoid; *S. T*, supratemporal; *TR. PAL.*, transpalatine. [x 4].


P.MX
MX.F.
O.N.C.
P.SP.
JU.
PRJ.
PTY.
EP.PTY.
IN.OT.
F.OV.
Q.
P.OT.
SQ.
S.T
S.T.F.
PAR.
PT.ORB.
ORB.SP.
OP.F.
PL.SUP.
FR.
F.SEP.
I.O.S.
P.FR.
NA.
MX.A.P
EX.N.

The Occipital Region

The occipital region is completely ossified and consists of four distinct bones, viz., the basioccipital, the paired exoccipital and the supraoccipital, all of which take part in bounding the foramen magnum. The occipital condyle is single, median and distinctly tripartite. This is in agreement with the generalization made by Goodrich (1930) stating that the occipital condyle is tripartite in the Lacertilia. Kingsley (1925) is mistaken in regarding the lacertilian occipital condyle to be formed entirely of basioccipital. The median ventral piece (pars condyloidea), which is the largest of the three pieces, is formed by the posterior end of basioccipital while the two lateral pieces are formed by the posterior ends of the exoccipitals. All bones of the occipital region are cartilage (replacing) bones.

The median BASIOCCIPITAL is a more or less triangular bone produced into a short truncated process on each side. The lateral processes are not horizontal but inclined ventrad. In the ventral view there is no demarcation between the body of the basioccipital and its processes, and the whole thing is a concave triangular structure to the posterior end of which a knob (pars condyloidea) is attached. In the dorsal view, the body of the basioccipital presents a deep concavity which, in continuation with a similar depression in the basisphenoid, forms a cup to accommodate the medulla oblongata. The pars condyloidea and the posterior surface of each lateral process present a flat surface which fits against the exoccipital.

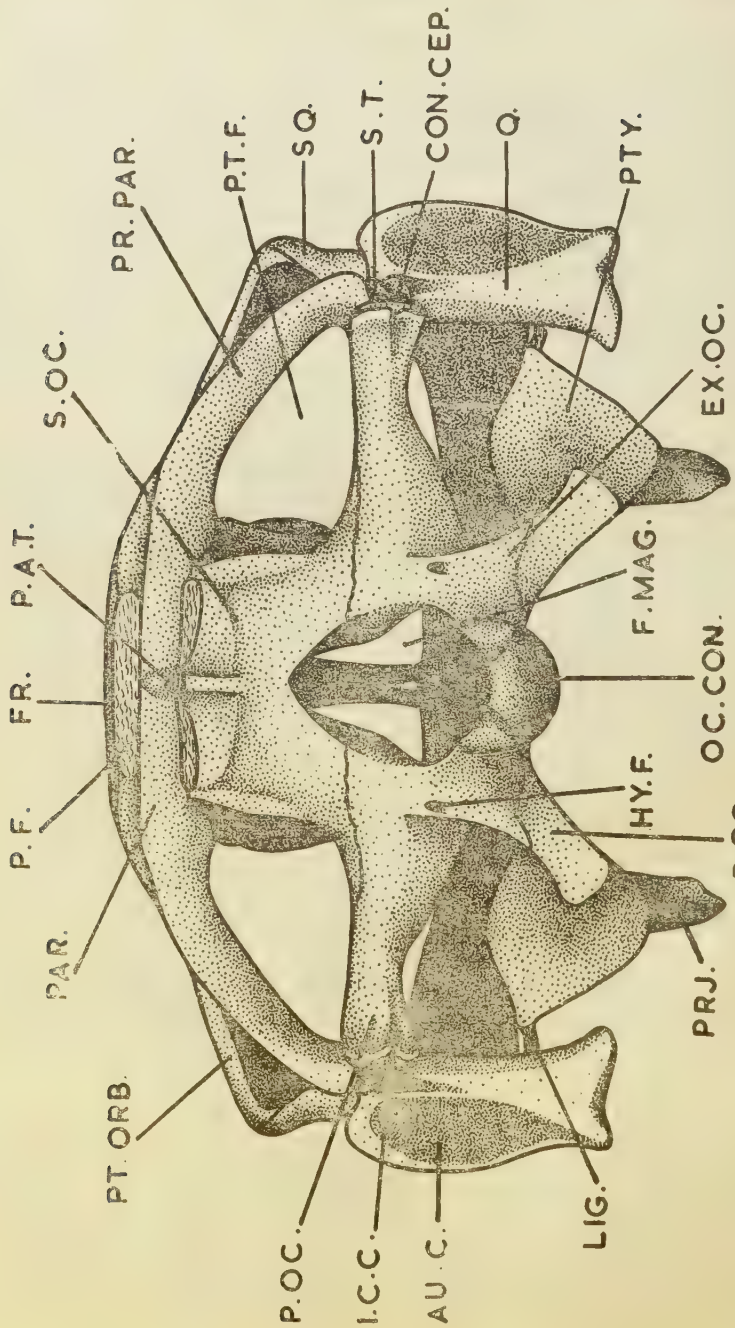


Basioccipital.
Left, dorsal view; right, ventral view.
B. SP. F., facet for basisphenoid; *EX. OC. F.*, facet for exoccipital; *P. CON.*, pars condyloidea. [x 5].

In a disarticulated skull the basioccipital is seen to have a broad truncated anterior margin. However, in a complete skull the posterior lateral processes and the edge of the basisphenoid overlap and hide the flat border

Lateral view of the skull.

EP. PTY., epipterygoid; *EX. N.*, external nostril; *F. OV.*, fenestra ovalis; *FR.*, frontal; *F. SEP.*, fenestra septi; *I. O. S.*, interorbital septum; *IN. OT.*, incisura otosphenoidea; *JU.*, jugal; *MX. A. P.*, ascending process of maxilla; *MX. F.*, maxillary foramen; *NA*, nasal; *O. N. C.*, orbitonasal canal; *OP. F.*, optic foramen; *ORB. SP.*, orbitosphenoid; *PAR*, parietal; *P. FR.*, prefrontal; *PL. SUP.*, planum supraseptale; *P. MX.*, premaxilla; *P. OT.*, pro-otic; *PRJ.*, pterygo-transpalatine projection; *P. SP.*, parasphenoid; *PT. ORB.*, postorbital; *PTY.*, pterygoid; *Q*, quadrate; *SQ.*, squamosal; *S. T.*, supratemporal; *S. T. F.*, supratemporal fossa. [x 7].


PR.PAR.
P.T.F.
SQ.
S.T.
CON.CEP.
Q.
PTY.
S.OC.
P.A.T.
FR.
P.F.
PAR.
EX.OC.
F.MAG.
OC.CON.
HY.F.
B.OC.
PRJ.
PT.ORB.
P.OC.
I.C.C.
AU.C.
LIG.

of the basioccipital, so that the latter appears to have a pointed anterior end. In the dorsal view the greater part of the anterior face of each process of the basioccipital presents an articulating surface covered over with a very thin sheet of cartilage and known as tuberculum spheno-occipital. A part of the inferior process of the pro-otic articulates with the tuberculum.

The EXOCCIPITAL of each side is an irregularly-shaped compound bone formed by the fusion of the exoccipital proper with the opisthotic of that side. In view of its compound nature and its topography, a number of alternative names such as oto-occipital, pleuro-occipital and lateral occipital have been suggested for it. However, by common usage, the name exoccipital is used also for the exoccipital-opisthotic complex.

The fusion between the opisthotic and the exoccipital proper is complete, but the two components can be delimited to some extent. The ventro-lateral triangular piece, which is in contact with the basioccipital all along and forms the lateral pieces of the occipital condyle, is the exoccipital proper. The rest of the bone, which is in contact on the anterior (inner) side with the pro-otic, and on the dorsal side with the supraoccipital, is the opisthotic. It forms by far the larger component of the composite exoccipital, and is produced outwards into the paroccipital process. At the junction of the exoccipital proper and the opisthotic, almost at the base of the paroccipital process, there is a small slit-like foramen, the hypoglossal foramen. It can be seen in the posterior view of the skull.

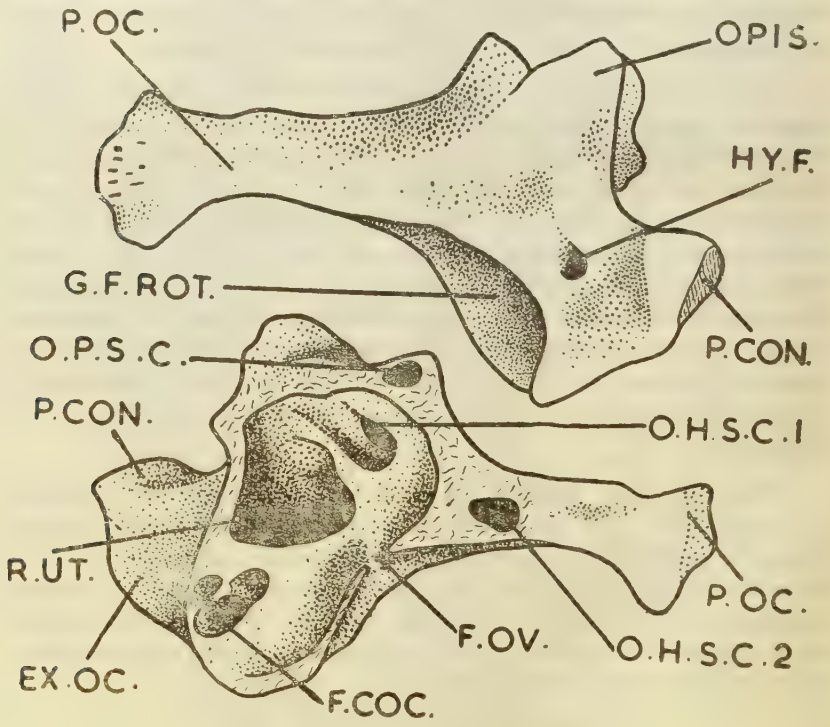
The OPISTHOTIC part of the bone forms the posterior part of the auditory capsule, and gives out a stout, horizontal paroccipital process. This process is directed outwards and backwards and supports, at its outer end, the supratemporal, the supratemporal process of the parietal (processus parietalis) and the quadrate. On its antero-ventral aspect it has a prominent groove, the sulcus venae jugularis, which continues downwards and forwards on the pro-otic.

Posterior view of the skull.

AU. C., auditory cup; *B. OC.*, basioccipital; *CON. CEP.*, condylus cephalicus; *EX. OC.*, exoccipital; *F. MAG.*, foramen magnum; *FR.*, frontal; *HY. F.*, hypoglossal foramen; *I. C. C.*, intercalary cartilage; *LIG.*, ligament; *OC CON.*, occipital condyle; *PAR.*, parietal; *P. A. T.*, processus ascendens tecti; *P. OC*, paroccipital process; *PRJ.*, pterygo-transpalatine projection; *PR. PAR.*, processus parietalis; *P. T. F.*, posterior temporal fossa; *PT. ORB.*, postorbital; *PTY.*, pterygoid; *Q.*, quadrate; *S. OC.*, supraoccipital; *SQ.*, squamosal; *S.T.*, supratemporal; *S.T.F.*, Supratemporal fossa. [x 7].

In a disarticulated exoccipital, on the dorsal side of the opisthotic part, almost in the thickness of the wall of the capsule, there is a foramen leading into the passage for the posterior vertical semi-circular canal of the internal ear. This semi-circular canal can be discerned on the external surface as a narrow whitish band. On the anterior surface of the paroccipital process, at its root, there is a foramen leading into the passage for the horizontal semi-circular canal.

In the fossa of the opisthotic part of the auditory capsule there is an oval depression or recess, a small foramen on the dorsal and outer side of

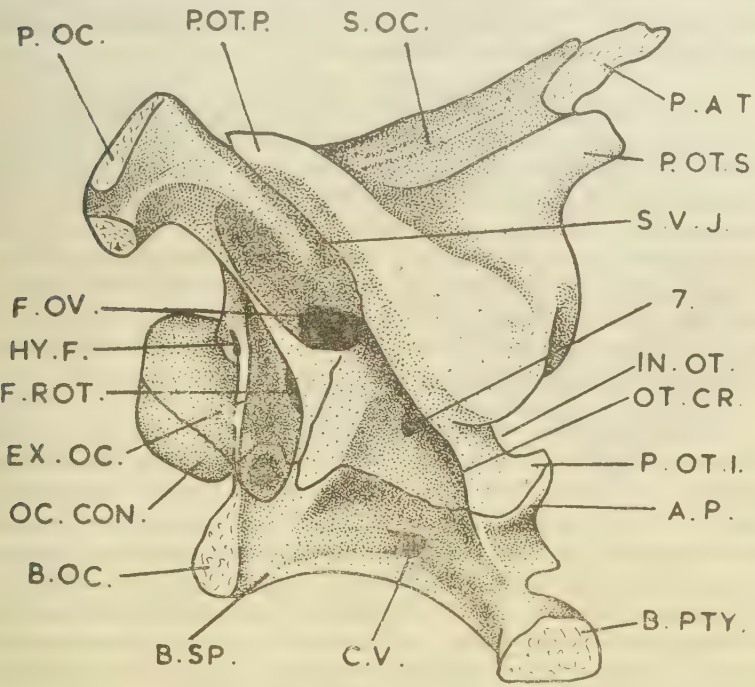


Exoccipital.

Top, posterior view; bottom, anterior view.

EX. OC., exoccipital proper; *F. COC.*, fenestra cochleae; *F. OV.*, dent representing posterior wall of fenestra ovalis; *G. F. ROT.*, groove leading to fenestra rotunda; *HY. F.*, hypoglossal foramen; *O. H. S. C. 1.*, mesial opening of horizontal semicircular canal; *O. H. S. C. 2.*, lateral opening of horizontal semicircular canal; *OPIS.*, opisthotic part; *O. P. S. C.*, opening of posterior vertical semicircular canal; *P. CON.*, pars condyloidea; *P. OC.*, paroccipital process; *R. UT.*, recessus utriculi and posterior ampulla. [x 7.5].

this recess, and another small foramen on its ventral and inner side. The central depression lodges the recessus utriculi and the posterior ampulla leading into the posterior semi-circular canal. The outer dorsal foramen leads into the passage for the horizontal semi-circular canal, while the inner and ventral foramen (fenestra cochleae) leads on to the fenestra rotunda. The fenestra rotunda is a large, elliptical opening on the ventral side, at the junction of the exoccipital part and the opisthotic. A triangular process of the exoccipital proper extends beyond the fenestra rotunda so that the latter cannot be seen in the posterior view of the skull.



Side view of the occipital segment and allied bones.

A. P., alar process; *B. OC.*, basioccipital; *B. PTY.*, basipterygoid process; *B. SP.*, basisphenoid; *C. V.*, canalis vidianus; *EX. OC.*, exoccipital; *F. OV.*, fenestra ovalis; *F. ROT.*, fenestra rotunda; *HY. F.*, hypoglossal foramen; *IN. OT.* incisura otosphenoidea; *OC. CON.*, occipital condyle; *OT. CR.*, otosphenoidal crest; *P. A. T.*, processus ascendens tecti; *P. OC.*, paroccipital process; *P. OT. I.*, anterior inferior process of pro-otic; *P. OT. P.*, posterior process of pro-otic; *P. OT. S.*, anterior superior process of pro-otic; *S. OC.*, supraoccipital; *S. V. J.*, sulcus venae jugularis; 7, facial foramen for the 7th nerve. [x10].

On the ventro-lateral aspect of the opisthotic part of the auditory capsule there is a dent in the wall leading on to a groove in the anterior face of the paroccipital process. This dent represents the posterior half of the fenestra ovalis, which is completed in front by the pro-otic.

In the inner (anterior) view two foramina are seen at the junction of the exoccipital proper and the opisthotic. The dorsal foramen is slit-like and can be seen also in the posterior view of the skull. It is the hypoglossal foramen. The ventral foramen, which is larger than the former and oval in outline, is the internal opening of the fenestra rotunda. It lies more or less in the wall of the opisthotic part of the auditory capsule and communicates with the fenestra cochleae as well.

The SUPRAOCCIPITAL, which is formed by the fusion of the supraoccipital proper and the epiotic, is a median bone forming the roof of the occipital region of the cranium and also the dorsal part of the auditory capsule. Thus it is in contact with the parietal, opisthotic part of the exoccipital, and the pro-otic. Dorsally, it lies at a lower level than the fused parietals. It slopes sharply in the antero-posterior direction making an angle of about 60° with the roof of the skull. It slopes a little also on each side. In the living animal the space above the supraoccipital is filled by the thick occipito-vertebral muscles so that the difference in level between the parietal and the supraoccipital regions cannot be noticed.

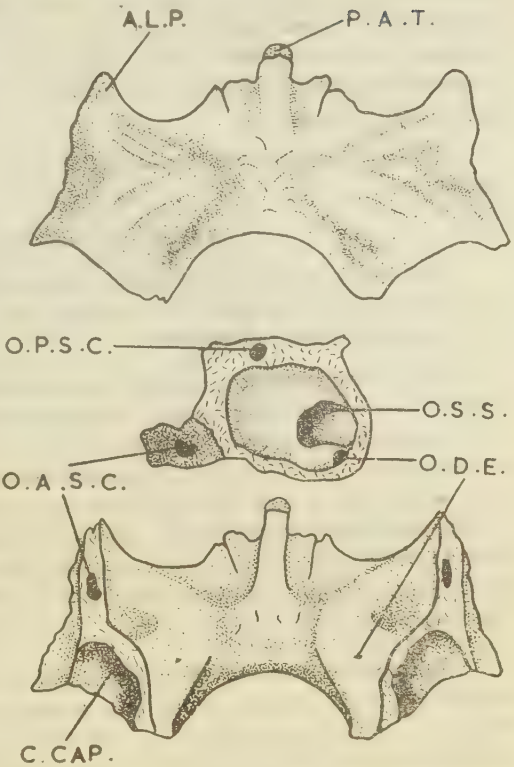
In the dorsal view the supraoccipital is rectangular in outline, with a deep semi-circular notch on its posterior border completing the foramen magnum. The middle part of the supraoccipital is very thin except for a dense mid-dorsal occipital ridge or crest projecting anteriorly as a median bony process with cartilage at its tip. This process is the processus ascendens tecti and fits into a deep notch on the posterior and under surface of the composite parietal. Thus, in keeping with the kinetic nature of the skull there is a ball-and-socket joint between the supraoccipital and the parietal. *Uromastix* agrees with *Lacerta* (Siebenrock, 1894), *Hemidactylus* (Mahendra, 1949) and *Calotes* (Iyer, 1943), and differs from *Varanus* (Bahl, 1937) in having a bony processus ascendens tecti tipped with cartilage. In the latter the processus is completely cartilaginous.

In addition to this median articulation between the supraoccipital and the composite parietal, further articulation between the two is provided by two short antero-lateral processes of the supraoccipital. The space between the processus ascendens and the two antero-lateral processes is filled with a fibrous membrane supported by cartilage. The connexion

between the supraoccipital and the parietal is, thus, not sutural but allows some vertical movement between the two bones.

In the anterior half, immediately behind the tip of the antero-lateral process, the supraoccipital articulates with the prootic. As described below, the posterior lateral part of the supraoccipital is in contact with the opisthotic part of the exoccipital.

The disarticulated supraoccipital presents, on its postero-ventral side, two cup-like structures each of which forms the dorsal part of the auditory capsule of its side. On the inner wall of each cup there is an oval foramen leading into a tubular depression which lodges the sinus superior of the labyrinth. This tube leads both anteriorly and posteriorly into the upper parts of the anterior and posterior vertical semicircular canals The opening for the anterior semi-circular canal lies on the lateral border of the bone almost midway between the anterior rim of the auditory cup and the tip of the antero-lateral process of the bone. The opening of the posterior semi-circular canal lies in the thickness of the dorsal wall of the auditory cup at the posterior edge of the bone.



Supraoccipital.

Top, dorsal view; middle, postero-lateral view showing cavum capsularis; bottom, ventral view.

A. L. P., antero-lateral process; *C. CAP.*, cavum capsularis; *O. A. S. C.*, opening of anterior semicircular canal; *O. D. E.*, opening of ductus endolymphaticus; *O. P. S. P.*, opening of posterior semicircular canal; *O. S. S.*, opening of tube lodging sinus superior of labyrinth; *P. A. T.*, processus ascendens tecti. [x 10].

On the inner wall of each cup, a little below the aperture of the

tubular depression there is a minute aperture leading into a tunnel which lodges the ductus endolymphaticus. This tunnel opens to the outside, i. e. in the cranial cavity, by a very fine aperture, aqueductus vestibuli, lying on the outer side of the cup, a little anterior to the other opening of the tunnel.

The supraoccipital forms the roof of the medulla oblongata and the cerebellum.

The Parietal Region

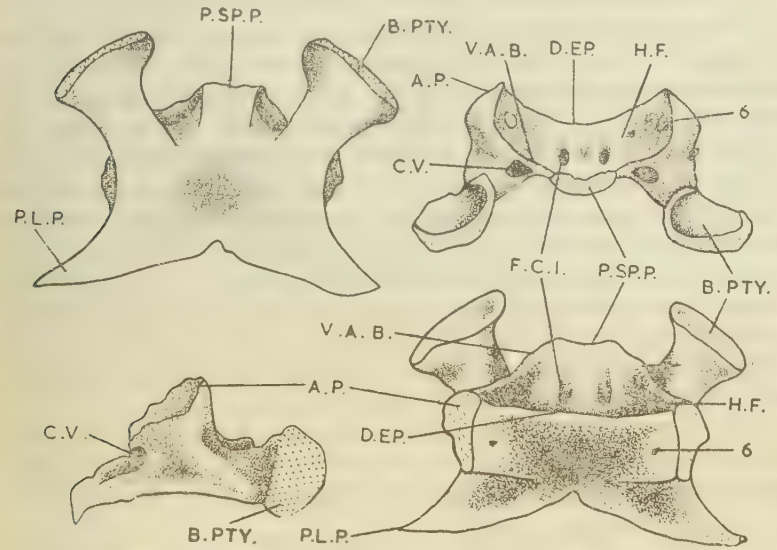
The parietal region of the skull comprises the fused parietals above and the basisphenoid below. The parietals are membrane bones, whereas the basisphenoid is a replacing bone.

The BASISPHENOID is a more or less quadrangular bone lying immediately in front of the basioccipital. It forms the floor of the cranial cavity below the midbrain and the anterior part of the medulla oblongata. On the ventral side the basisphenoid presents a slightly concave surface. On the posterior side it is produced into two processes directed backwards, outwards, and somewhat downwards. These processes fit against the antero-lateral surface of the lateral processes of the basioccipital. Thus a little of the dorsal posterior surface of the basisphenoid is overlapped by the basioccipital.

The anterior border of the basisphenoid is double : there is a dorsal anterior border (dorsum ephippi) and a ventral anterior border. The two borders are formed as a result of the presence at the anterior end, of a large and deep depression called the hypophysial fossa, which lodges the infundibulum and the hypophysis of the brain. In *Uromastix* the hypophysial fossa is broader and shallower than in *Varanus*. The dorsal anterior border is concave and is produced on each side into a very short process corresponding to the alar process. On the tip of the alar process and for some distance behind, there is a triangular surface for articulation with the pro-otic. It is with the dorsum ephippi that the membrane forming the antero-ventral floor of the cranium is attached.

The ventral anterior border of the basisphenoid is triangular. The apex of the triangle, with which the parasphenoid articulates, may be said to correspond with the parasphenoid process in *Varanus* and other forms. On each side of the base of the triangle, just in front of the alar process, the basisphenoid is produced antero-laterally into a stout process, the basipterygoid process. The basipterygoid process is expanded at its extremity and articulates with the pterygoid through a cartilaginous

meniscus. In this respect the basipterygoid process of *Uromastix hardwickii* resembles that of *Agama hispida* (Broom, 1922), *Varanus* (Bahl, 1937), *Scincus* (El-Toubi, 1938), and *Calotes* (Iyer, 1943), and differs from that of *Hemidactylus* (Mahendra, 1949).



Basisphenoid.

Top left, ventral view ; top right, anterior view ; bottom left, lateral view (right, side) ; bottom right, dorsal view.

A. P., alar process ; *B. PTY.*, basipterygoid process ; *C. V.*, canalis vidianus ; *D. EP.*, dorsum ephippi (dorsal anterior border); *F. C. I.*, foramen caroticum internum; *H. F.*, hypophysial fossa ; *P. L. P.*, posterior lateral process ; *P. SP. P.* parasphenoid process ; *V. A. B.*, ventral anterior border ; 6, foramen for the 6th nerve. [x 3].

The dorsal surface of the basisphenoid is concave from side to side and is also higher in front than behind. This concavity, together with the concavity on the dorsal surface of the basioccipital, forms a shallow depression into which fits the anterior part of the medulla oblongata.

On the dorsal surface of the basisphenoid, at the base of each alar process, there is a small foramen for the exit of the sixth nerve. This foramen leads into a short, hair-like canal opening in front into the dorso-lateral part of the hypophysial fossa.

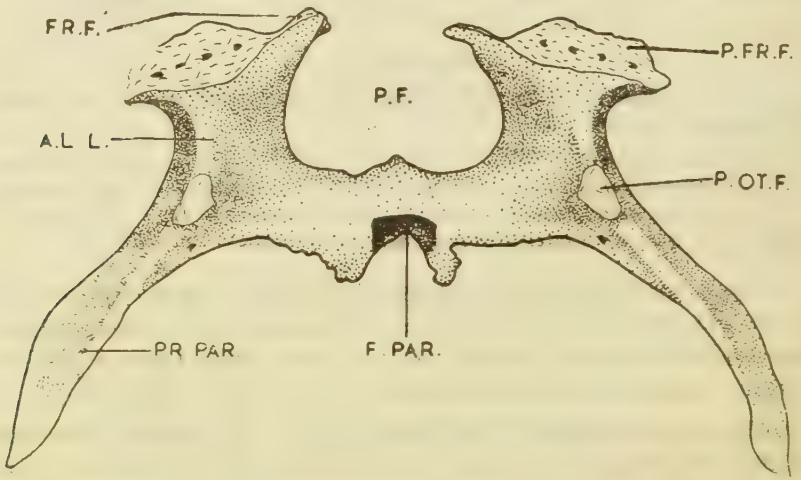
In the side view of the disarticulated basisphenoid a foramen can be seen in between the posterior lateral process and the basipterygoid process.

This foramen leads into a tunnel, the canalis vidianus, which pierces the base of the basipterygoid process. It opens in front at the root of the basipterygoid process in the angle between the latter and ventral anterior border. Through the canalis vidianus passes the palatine branch of the internal carotid artery and the palatine branch of the facial nerve.

On the floor of the hypophysial fossa there are two foramina, one on each side of the base of the parasphenoid process. This foramen, the foramen caroticum internum, leads into a canal communicating with the canalis vidianus, and it is through this foramen that the cranial branch of the internal carotid enters the hypophysial fossa from the canalis vidianus.

The bone formed by the fusion of the two PARIETALS is more or less H-shaped. The parietals are united to form a single bone in all Agamidae (Smith, 1935). It articulates by its anterior longitudinal limbs with the frontal in front, and with the postorbital on the sides. By its posterior longitudinal processes which are long, strong and laterally compressed, and are known as the supratemporal processes (processus parietalis), the parietal articulates behind with the supratemporal (tabular), squamosal and the paroccipital process of the exoccipital.

The anterior longitudinal limbs of the composite parietal are short and thick and have two facets on the ventral surface at the anterior end. One of these facets is antero-ventral and abuts against the frontal, while



Ventral View of Parietal.

A. L. L., anterior longitudinal limb ; *F. PAR.*, fossa parietalis ; *FR. F.*, facet for frontal ; *P. F.*, pineal fossa ; *P. FR. F.*, facet for postorbital ; *P. OT. F.*, facets for pro-otic and epipterygoid ; *PR. PAR.*, processus parietalis (posterior longitudinal limb). [x 9].

the other is antero-lateral and articulates with the postorbital. The space between the two limbs is the pineal (parietal) fossa, which is completed in front by the frontal. In the complete skull the pineal fossa is covered over by a tough fibrous membrane, near the anterior end of which there is a small aperture, the parietal or pineal foramen.

The supratemporal processes are divergent, long and laterally compressed. Moreover they are thinner at the ends. At the root or the anterior portion of each process, on the ventral side, there is an articulating surface against which fit the pro-otic and the antero-lateral process of the supraoccipital. Just external to this surface is the facet for the epipterygoid or columella cranii. Looked at from the side, the supratemporal processes are somewhat arched and are narrower in the middle than at the ends.

On the postero-ventral surface of the composite parietal there is a deep but narrow funnel shaped depression, the fossa parietalis, into which fits the anterior tip of the processus ascendens tecti of the supraoccipital. In the dorsal view of the skull, the position of the fossa is marked by a prominent semi-circular dent or notch in the posterior border of the transverse bar of the composite parietal. On the anterior border of this bar, and thus projecting into the pineal fossa, is a very small tooth-like projection.

On the dorso-posterior side of the transverse bar, on either side of the dent of the fossa parietalis, there is a concavity for the attachment of the occipito-vertebral muscles.

On the inner or mesial side of the compressed supratemporal process, just behind its union with the transverse bar of the parietal, there is a small foramen which communicates with numerous small spaces in the anterior longitudinal process of the bone. At the tip of the anterior longitudinal processes these spaces open by 3-5 minute apertures.

The Frontal Region

The frontal region comprises the united frontals above, the parasphenoid below and a pair of orbitosphenoids supporting the antero-ventral part of the cranium and surrounding the optic chiasma. The frontal and parasphenoid are membrane bones, whereas the orbitosphenoids are replacing bones. These bones cover only a small portion of the cranial cavity ; its greater part is covered by cartilaginous and membranous tracts. Only the anterior part of the cerebral hemispheres and the olfactory stalks lie in the frontal region.

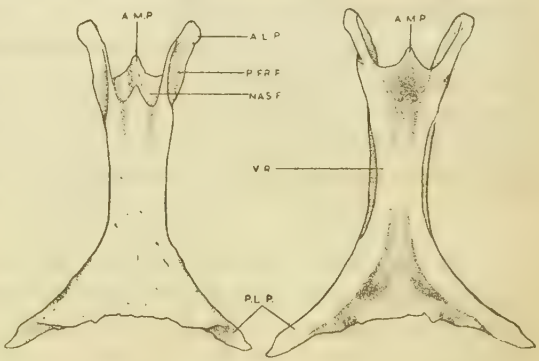
The cranial cavity, in the frontal region, is very much reduced and

confined to the dorsal part of the skull. The brain is obliquely placed. The portion of the cerebral hemispheres in this region is covered by the frontal above and supported by cartilage and fibrous membrane below. Thus the anteriormost portion of the cerebral hemispheres rests in a cartilage representing the planum supraseptale. The optic chiasma is surrounded by two orbitosphenoids. The olfactory stalks lie below the frontal, enclosed in a membranous sheath and not in a bony canal as in *Varanus*.

The two orbits lie very close together, being separated only by a thin, vertical interorbital septum. Thus, in this region the cranial cavity is very narrow and reduced. Such a skull is said to be of the tropibasic (tropitrabic) type.

The PARASPHENOID is a long, slender bone flattened dorso-ventrally and resembling the blade of a dagger in shape. It lies in the mid-ventral line, below the interorbital septum, and articulates with the parasphenoid process of the basisphenoid behind. In front it extends almost to the point where the two pterygoids converge towards the middle line, i. e. to about half the length of the interorbital septum. In a freshly prepared skull the parasphenoid lies slightly obliquely, its anterior end being somewhat raised up. In shape and form the parasphenoid of *Uromastix* resembles that of *Varanus* and *Calotes*, but differs from that of *Sphenodon*.

The two FRONTALS fuse to form a longish bone, narrow anteriorly, broad posteriorly. The fusion of frontals occurs in all Agamidae (Smith, 1935). The posterior edge of the composite frontal is not straight but concave, so that the bone appears to bifurcate or to give off a stout outwardly directed process on each side. Near its tip each posterior lateral process of the frontal has a postero-dorsal articulating surface abutting against the composite parietal and the postorbital. The concavity between the two posterior lateral processes of the frontal completes the



Frontal.

Left, ventral view ; right, dorsal view.

A. L. P., anterior lateral process ; *A. M. P.*, anterior median process ; *NAS. F.*, facet for nasal ; *P. FR. F.*, facet for prefrontal ; *P. L. P.*, posterior lateral process ; *V. R.*, ventral ridge. [x 4].

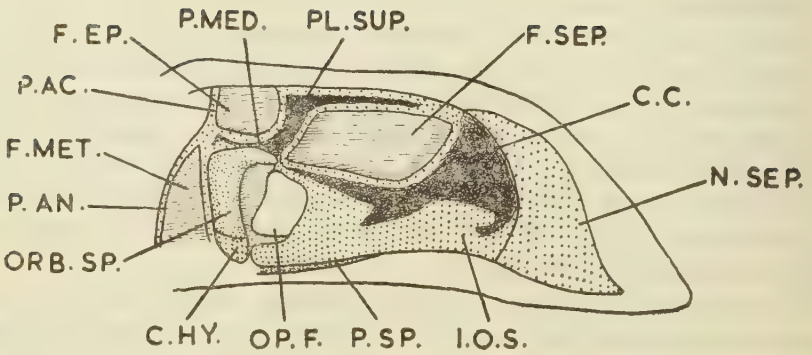
pineal fossa. *Uromastix* differs from *Varanus* and resembles *Calotes* in having a pineal fossa bounded by frontal and parietal.

The anterior end of the frontal is not smooth but is produced into three short processes, one very small median process and two somewhat longer, slender, laterally compressed, anterior lateral processes. On each side, between the median and the lateral processes, there is a prominent articulating surface which is overlapped by the nasal in front. On the outer side of each anterior lateral process there is a facet for articulation with the prefrontal.

The dorsal surface of the composite frontal is smooth except for the anterior facets mentioned above. On the ventral side, however, the surface is not smooth. The lateral edges of the bone are seen to be thicker than the middle portion. Thus in the ventral view the lateral edges give the appearance of a ridge which continues on to the lateral processes, both anterior and posterior. Consequently, when seen with transmitted light, the anterior part of the composite frontal shows a triangular translucent area in the middle of which there is an opaque streak, the root of the anterior median process. In *Varanus* (Bahl, 1937) and *Hemidactylus* (Mahendra, 1949) the latero-ventral ridges are very prominent and meet in the mid-ventral line to enclose a bony canal, the canalis olfactorius. The latter is absent in *Uromastix* as also in *Calotes*.

The anterior and ventro-lateral walls of the cranium are formed partly by cartilage and partly by thick fibrous membrane, and are unossified except for the two orbitosphenoids, one on each side of and a little behind the optic fenestra. The cartilaginous part represents the planum supraseptale and its extensions. The planum supraseptale is the anterior portion of the orbital cartilages and is trough shaped. Its posterior portion, which rests on the dorso-posterior edge of the interorbital septum, is wide, V-shaped in transverse section, and lodges the anterior end of the cerebral hemispheres. The anterior portion of the planum supraseptale rests on the dorsal edge of the interorbital septum and runs for about half the length of the septum. It is not very wide and lodges the canalis olfactorius which is membranous. Near the anterior end its walls lose rapidly in height till they disappear. The greater part of the planum supraseptale is calcified.

From each postero-lateral edge of the planum supraseptale there runs a very short and much reduced oblique cartilage known as the planum (taenia) medialis. A little laterally and posteriorly the planum medialis meets three cartilages, two ventral and one dorsal, joined together to form an inverted Y. The dorsally directed cartilage is narrow and represents



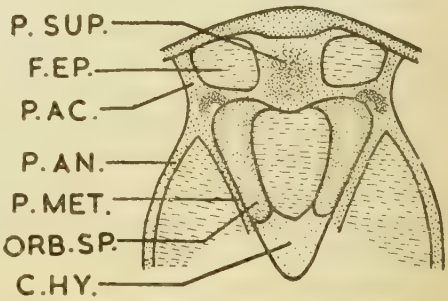
Antero-ventral wall of cranium and interorbital septum.

C. C., calcified cartilage of interorbital septum ; *C. HY.*, cartilage hypochiasmatica ; *F. SEP.*, fenestra septalis ; *I. O. S.*, interorbital septum ; *N. SEP.*, nasal septum ; *OP. F.*, optic fenestra ; *ORB. SP.*, orbitosphenoid ; *P. AC.*, pila accessoria ; *P. AN.*, pila antotica ; *PL. SUP.*, planum supraseptale ; *P. MED.*, planum medialis ; *P. SP.*, parasphenoid.

the pila accessoria of the chondrocranium. Of the two ventral cartilages, the one directed outwards is very narrow and represents the pila antotica, while the one directed inwards is pila metoptica. The greater part of the pila metoptica is ossified to form the orbitosphenoid.

Below the optic foramen the two pilae metopticae meet and form a broad cartilage corresponding to the subiculum infundibuli and the cartilage hypochiasmatica.

The spaces between the various cartilages are covered over with a membrane and represent the fenestrae of the chondrocranium. The optic fenestra, transmitting the optic nerve, is bounded in front and divided into two by the posterior edge of the interorbital septum. On its ventral side lie the cartilage hypochiasmatica and subiculum infundibuli. It is bounded behind and on the sides by the pila metoptica and the orbitosphenoid and above by the taenia medialis.



Antero-ventral wall of cranium.

C. HY., cartilage hypochiasmatica ; *F. EP.*, fenestra epiotica ; *ORB. SP.*, orbitosphenoid ; *P. AC.*, pila accessoria ; *P. AN.*, pila antotica ; *P. MET.*, pila metoptica ; *P. SUP.*, planum supraseptale.

The metoptic fenestra is bounded in front by the pila metoptica and behind by the pila antotica. It ends dorsally at the junction of the pila metoptica and pila antotica with the planum medialis.

The fenestra epiotica is bounded in front by the planum supraseptale, below by the taenia medialis, behind by the pila accessoria and above by the frontal bone (which is ossified in relation with the taenia marginalis).

The ORBITOSPHENOIDS are small, antero-posteriorly flattened, thin, somewhat curved bones ossified in the pila metoptica. Each orbitosphenoid is somewhat broader dorsally, as the dorsal end seems to have been bent inwards (mesially) to form a beak-like process forming a part of the dorsal wall of the optic fenestra. The orbitosphenoid lies behind and on the sides of the optic fenestra.

The interorbital septum is a thin vertical plate of cartilage separating the two orbits. There is a small rhomboidal fenestra, the fenestra septis (or septalis) in its posterior dorsal region immediately in front of and below the planum supraseptale. This fenestra is covered with a transparent membrane. Quite a large portion of the interorbital septum is calcified : its anterior region is mainly calcified and there is a narrow zone of calcification just below the fenestra septis. The ventral region of the interorbital septum, however, consists of hyaline cartilage. A fenestra septis covered with membrane has been described also in *Lacerta*, *Varanus*, *Calotes* and many other Lacertilia.

THE SENSE CAPSULES

The auditory and olfactory capsules are intimately connected with the skull, but the optic or sclerotic capsule is free and unossified.

a. The Auditory Capsule

The auditory capsules are very closely associated with the occipital region of the cranium, and each of them is formed of three replacing bones, viz., the pro-otic, the opisthotic which has fused with the exoccipital, and the epiotic which has fused with the supraoccipital. The auditory capsule bulges into the cranial cavity and can easily be seen through the foramen magnum.

Two bones of the auditory capsule, namely the opisthotic and the epiotic, have been described above in connexion with the occipital region of the cranium. Only the pro-otic remains to be described.

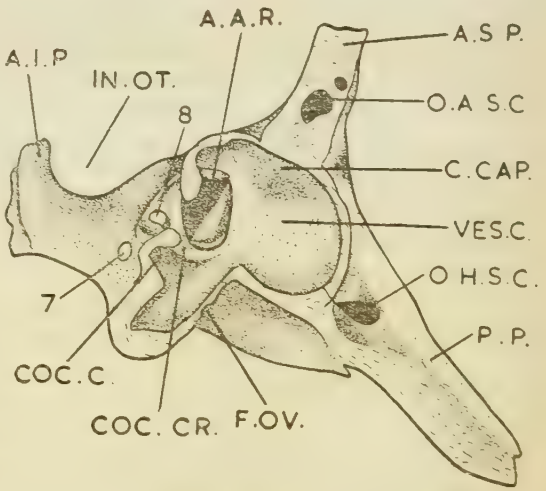
The PRO-OTIC is a tri-radiate bone in the occipital region of the skull, on the anterior side of the exoccipital. At the junction of its three processes or radii, the bone is hollowed out to form a cup-shaped depression which constitutes the anterior portion of the auditory capsule (cavum

capsularis). Two of the processes are directed forwards, one being the anterior dorsal or the anterior superior process and the other being the anterior ventral or anterior inferior process. The third process is directed outwards and backwards, and may be referred to as the posterior process.

The anterior superior process, known also as the parietal process of the pro-otic, is fairly long and narrow and articulates with the composite parietal on the ventral side of the root of the processus parietalis. The articulating surface for the pro-otic lies just in front of that for the antero-lateral process of the supraoccipital, and just internal to, but in continuation with that for the epipterygoid. The tip of the epipterygoid rubs against the tip of the anterior superior process of the pro-otic.

The anterior ventral or anterior inferior process of the pro-otic is short, stumpy and not uniformly thick. Its antero-dorsal border is thick, but the posterior portion is grooved by the sulcus vanae jugularis. The antero-dorsal edge of the bone is not flat but deeply concave. The anterior portion articulates with the basisphenoid at a facet just behind and on the outer side of the alar process. The rest of the anterior inferior process articulates with the tuberculum spheno-occipital cartilage on the antero-dorsal border of the process of the basioccipital.

The posterior process of the pro-otic fits along the anterior face of the paroccipital process of the exoccipital.



Posterior view of pro-otic.

A. A. R., anterior ampullary recess; *A. I. P.*, anterior inferior process; *A. S. P.*, anterior superior process; *C. CAP.*, cavum capsularis; *COC. C.*, cochlear cavity; *COC. CR.*, cochlear crest; *F. OV.*, dent forming a part of fenestra ovalis; *IN. OT.*, incisura otosphenoidea; *O. A. S. C.*, opening of anterior vertical semicircular canal; *O. H. S. C.*, opening of horizontal semicircular canal; *P. P.*, posterior process; *VES. C.*, vestibular cavity; *7*, foramen for facial nerve; *8*, foramen for the posterior root of auditory nerve. [x. 11].

With the exception of one-half the posterior edge and the tip of the anterior superior process,

the whole of the dorsal edge of the pro-otic articulates with the supra-occipital.

The central hollow portion of the pro-otic fits posteriorly against the opisthotic part of the exoccipital, and dorsally against the hollow cup of the supraoccipital. The hollows in the three bones combine to form a large chamber, the auditory capsule or cavum capsularis.

In the side view of the bone a deep concavity can be seen above and in front of the anterior inferior process. This concavity corresponds to the incisura otosphenoidea of *Sphenodon* (Guenther, 1867), *Lacerta* (Siebenrock, 1894), *Varanus* (Bahl, 1937) and *Calotes* (Iyer, 1943). In the living animal this space is covered over with a membrane. The 5th nerve leaves the cranial cavity through a foramen in this membrane.

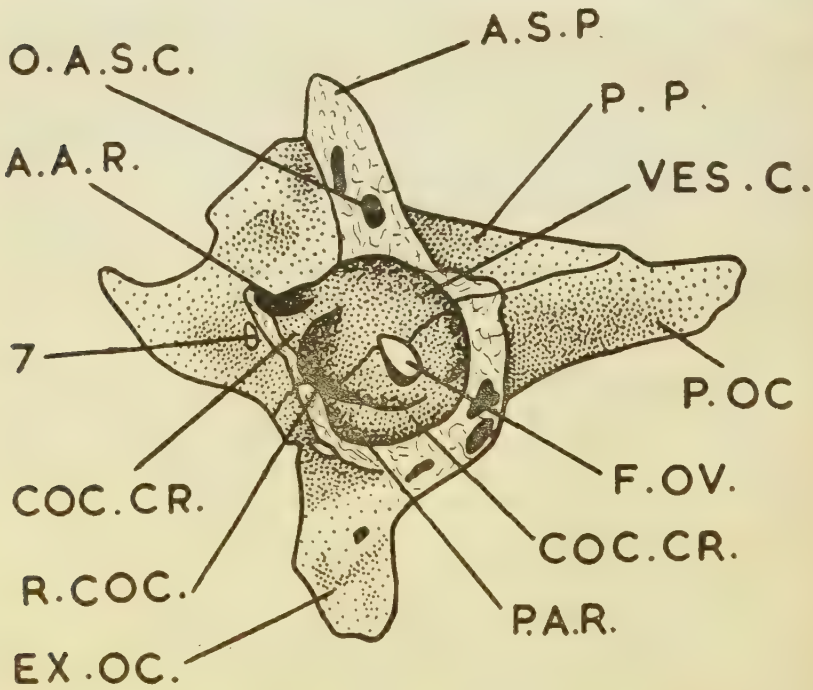
Along the outer surface of the pro-otic, and particularly noticeable on the anterior inferior process, there is a groove known as the sulcus venae jugularis. This groove continues above on to the paroccipital process of the exoccipital, and below on to the basisphenoid. In the region of the pro-otic this groove is bounded above by a prominent bony crest, the otosphenoidal crest. In the groove, just under the crest and in front of the fenestra rotunda, there is a foramen for the branches of the 7th nerve. In having a single facial foramen *Uromastix* differs from *Varanus* and agrees with *Calotes*. This foramen is easily recognizable in a disarticulated pro-otic as the only foramen in the thin portion of the anterior ventral process.

In the middle of the inner face of the anterior superior process, there is a perforation for the anterior vertical semi-circular canal. The remaining part of this canal lies in the corresponding portion of the supraoccipital. The opening of the horizontal semi-circular canal lies at the base of the posterior process on its posterior face. The greater part of this semi-circular canal lies in the pro-otic, while the remaining part lies in the opisthotic part of the exoccipital.

The central cup forms the anterior part of the cavum capsularis. Its greater part, especially that between the anterior superior and posterior processes, is shallow and represents the vestibular cavity. In the angle between the anterior superior and anterior inferior processes, there is a deep pit, the anterior ampullary recess. The ventral lip of the opening of this recess is formed by a prominent ridge known as the cochlear crest. The cochlear crest cuts off the pro-otic part of the cochlear cavity from the vestibular cavity. The cochlear cavity, thus, lies at the base of the anterior inferior process.

The cavity of the auditory capsule or the cavum capsularis is a globular space enclosed by the exoccipital, the pro-otic and the supraoccipital. It lodges the internal ear, and the parts of the cavum into which the utriculus, sacculus, cochlea, etc. fit, can be recognized easily in the dorsal view after the removal of the supraoccipital.

Examined thus, the cavum capsularis is seen to be divided by a narrow semi-circular ledge, the cochlear crest, into two parts. The upper larger part is the vestibular cavity lodging the utriculus and sacculus, while the lower, smaller pocket is the cochlear cavity for the cochlea and the lagena.



Cavum capsularis after the removal of supraoccipital.

A. A. R., anterior ampullary recess ; *A. I. P.*, anterior inferior process of pro-otic ; *A. S. P.*, anterior superior process of pro-otic ; *COC. CR.*, cochlear crest ; *EX. OC.*, exoccipital ; *F. OV.*, fenestra ovalis ; *O. A. S. C.*, opening of anterior vertical semicircular canal ; *P. A. R.*, posterior ampullary recess ; *P. OC.*, paroccipital process of exoccipital ; *P. P.*, posterior process of pro-otic ; *R. COC.*, recessus cochlearis ; *VES. C.*, vestibular cavity ; 7, foramen for facial nerve. [x 19].

In the anterior wall of the vestibular cavity there is a deep excavation or 'diverticulum', the anterior ampullary recess, which lodges the ampullae of the anterior vertical and the horizontal semi-circular canals. On the inner face of the anterior ampullary recess, there is a small round aperture through which a branch of the 8th nerve makes its entry. This aperture is situated very close to the one by which the 7th nerve makes its way out of the cranium. The anterior ampullary recess lies in the pro-otic, at the base of the anterior superior process. Because of its thin and translucent walls, the recess is recognizable even in the anterior view of the bone.

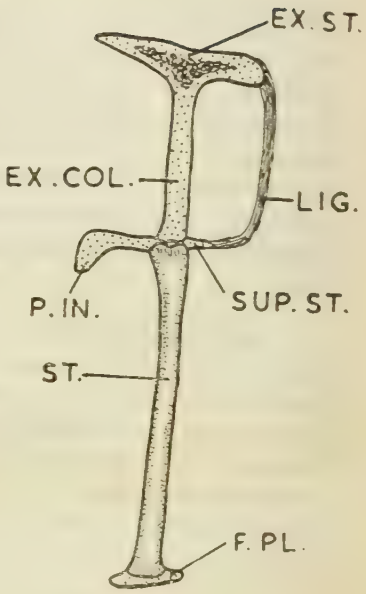
In the posterior part of the vestibular cavity lies a similar depression, the posterior ampullary recess, lodging the ampulla of the posterior vertical semi-circular canal. The opening for the posterior end of the horizontal semi-circular canal also lies in the posterior ampullary recess. The posterior ampullary recess lies in the opisthotic part of the exoccipital. In the posterior wall of the vestibular cavity, at the suture between the pro-otic and the opisthotic, there is a moderately large foramen for the posterior root of the 8th nerve.

The cochlear cavity lies ventrally to the vestibular cavity and extends inwards, i.e. towards the median axis of the skull. This pit-like extension is the recessus cochlearis which lodges the cochlea. A little posterior to the blind end of the recessus cochlearis, there is a groove leading into the fenestra rotunda. On the outer side of the recessus cochlearis lies the fenestra ovalis. The foramen, perforating that region of the opisthotic which forms the inner wall of the auditory capsule, also leads into the recessus cochlearis. The recessus cochlearis lies partly in the opisthotic.

The COLUMELLA AURIS is a derivative of the hyoid arch skeleton and extends between the fenestra ovalis and the tympanic membrane. It consists of a proximal (inner) or stapedial region and a distal (outer) extrastapedial region. The stapedial region comprises a slender bony rod, the stapes, provided at its proximal end with a broad, mainly cartilaginous footplate embedded in the membrane covering the fenestra ovalis. The greater part of the stapes is hollow and in the transverse section its lumen is seen to be full of red blood corpuscles. The extrastapedial region is cartilaginous and forms a rod, the extrastapes or hyostapes, which is flattened at its outer or distal end into an extrastapedial or insertion plate embedded in the tympanic membrane.

There is a joint between the stapes and the extrastapes. Arising from the ventral side of this joint there is a triangular process, the processus internus, attached by its narrow end partly to the extrastapes. The processus internus is directed downwards and forwards. From the dorsal side of this joint, i. e. on the side away from where the processus internus is attached, arises a short ligamentous process. This is the ligament of the processus dorsalis or the suprastapedial ligament. A strong ligament connects the insertion plate with the ligament of the processus dorsalis. In its shape and disposition the columella auris of *Uromastix* resembles that of *Calotes versicolor* (Iyer, 1943).

The quadrate shows a thin wing-like extension along the whole of its external aspect. This wing is not quite flat and straight but shows, on its posterior aspect, a cup-shaped depression, the auditory cup. The anterior border of the tympanum is attached to the rim of the auditory cup. On the other three sides the tympanum is attached to the muscles by connective tissue.



Columella uris.

EX. COL., extracolumellar cartilage ; *EX. ST.*, extrastapedial or insertion plate ; *E. PL.*, footplate ; *LIG.*, ligament ; *P. IN.*, processus internus ; *ST.*, stapes or otostapes; *SUP. ST.*, suprast apedial (ligament of processus dorsalis). [x 10].

b. The Optic Capsule

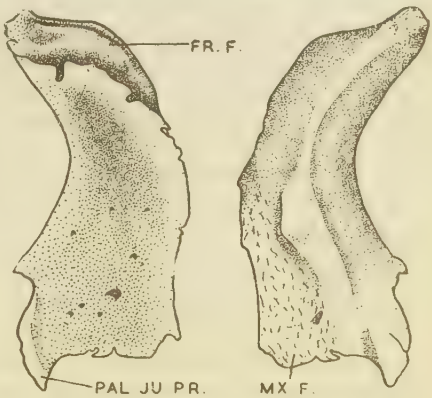
The outermost covering or the sclerotic of the eye is cartilaginous and is supported externally by a ring of twelve sclerotic ossicles. The sclerotic ossicles are irregular in shape and overlap each other without any precise order. These are the only bones in association with the optic capsule, which remains free from the skull. It is, however, surrounded and protected by a number of bones in this region of the skull.

The PREFRONTAL is a curved bone and forms the antero-dorsal, and a greater part of the anterior, walls of the orbit. Its dorsal narrower end takes the form of a stout, flat, conical, backwardly directed process which articulates with the facets on the antero-lateral processes of the frontal.

Antero-dorsally the prefrontal articulates with the nasal and anteriorly with the ascending process of the maxilla.

Beddard (1905) found that in *Uromastix aegyptia (=U. spinipes)* the frontal sends a thin forwardly and outwardly directed process between the prefrontal and nasal of each side and reaches the nasal vacuity. El-Toubi (1945) found the same condition in some specimens of *U. aegyptia*, but he observed that there was considerable variation in the nasal region of *Uromastix* in this respect. A good deal of variation was indeed observed in *U. hardwickii* in the length of the antero-lateral processes of the frontal. In most cases they are very short, hardly longer than the median process ; but in some cases they may be somewhat longer, and in rare cases more than half as long as the distance between the posterior border of the nasal fossa and the anterior edge of the frontal. It may be mentioned that although in the course of the present investigation about 3 dozen skulls of *U. hardwickii* were examined, yet none of them showed the condition described by Beddard (*op. cit.*).

In the side view of the skull, the prefrontal is seen to have a broad ridge produced by a concavity on the mesial (inner) side of the bone. This ridge divides the bone into a posterior face which forms the anterior wall of the orbit, and a lateral face. A disarticulated prefrontal shows a wide facet on its lateral face which is overlapped by the ascending process of the maxilla. At the lower border, the posterior face of the prefrontal meets a short broad ascending process of the palatine. The joint between the prefrontal and palatine is sutural and not through an intervening area of cartilage as in *Varanus* (Bahl, 1937).



Prefrontal.

Left, inner view ; right, outer view.

FR. F., facet for frontal and nasal; *MX. F.*, facet for ascending process of maxilla ; *PAL. JU. PR.*, process for articulation with palatine and jugal. [x 8].

In the angle between the ascending process and the horizontal part of the maxilla, there is a small, oblique, slitlike aperture, the orbitonasal (lachrymonasal ?) canal separating this part of the maxilla from the prefron-

tal. A very narrow process of the prefrontal cuts off the palatine from this aperture, and meets the tip of the jugal at the posterior border of the aperture.

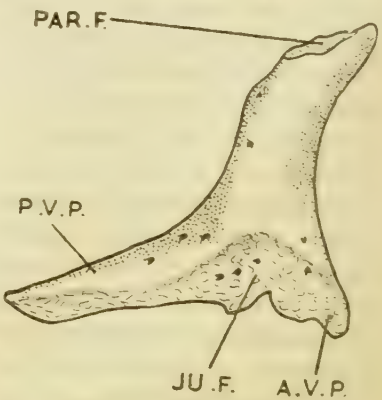
The concavity on the inner (mesial) side of the prefrontal forms the postero-lateral portion of the olfactory chamber.

There is no lachrymal in *Uromastix hardwickii*, as also in *U. aegyptia* (El-Toubi, 1945). Beddard (1905) and Sedgwick (1905) have also not sketched a lachrymal in the skull of *Uromastix*. According to de Beer (1937) a lachrymal is absent in many Lacertilia. Mahendra (1949) describes the single bone at the anterior end of the orbit of *Hemidactylus flaviviridis* as representing the fused lachrymal, prefrontal and perhaps also the supra-occipital. The same could be the case in *Uromastix* also but a proof could be afforded only by the study of the development of the skull.

The posterior border of the the orbit is formed by a POSTORBITAL. The postorbital is a column-like bone with a bifurcated ventral end. Dorsally it articulates with the antero-lateral end of the parietal and the tip of the postero-lateral process of the frontal. Ventrally the bifurcated end of the postorbital rests on the jugal. The two laterally directed parts or processes formed as a result of bifurcation are not equal : the posterior process is stouter and longer. The facet on the jugal is not situated on the crest of the bone but somewhat on its inner side.

In most specimens the postorbital does not articulate with the squamosal : at the most their pointed tips come in close proximity or rarely in contact.

There is a good deal of confusion in the literature regarding the name of this bone. Sedgwick (1905) sketched only one bone in the postorbital region of the skull of *Uromastix* and called it the postfrontal. Camp (1923) described only one bone in this region in the skull of *Heloderma, Lialis* and most Scincidae, and called it the postfrontal, declaring the postorbital to be absent. El-Toubi (1938) regarded the single bone in the postorbital region of the skull of *Scincus scincus* as postorbital and postfrontal combined. On the other hand Gegenbaur (1898) in his



Outer view of postorbital.

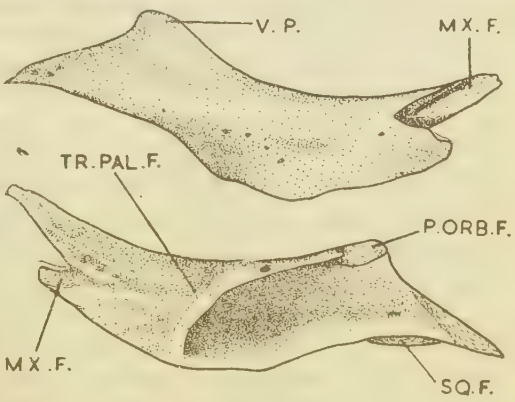
A. V. P., anterior ventral process ; *JU. F.*, facet for jugal ; *PAR. F.*, facet for parietal and frontal; *P.V.P.*, posterior ventral process. [x 10].

sketch of the postorbital region of the skull of *Uromastix* showed a very small postorbital lying between parietal and jugal, and represented the postfrontal as absent. Siebenrock (1895) found that the postfrontal was completely absent in most Agamidae. Beddard (1905) found that in *Uromastix aegyptia* both postfrontal and postorbital are present but the former is very much smaller. El-Toubi (1945) in his studies on the cranial osteology of *U. aegyptia* observed that although both postfrontal and postorbital are present in the majority of cases, the latter has a tendency towards disappearance, and may be absent on one or both sides of the skull.

In *Uromastix hardwickii* there is a single bone in the postorbital region of the skull. Although it does not usually articulate with the squamosal, as a postorbital typically does, yet the condition described by El-Toubi (*op. cit.*) in *U. aegyptia* is sufficient to prove that the bone under consideration is properly called the postorbital.

There are no supraorbital and postfrontal bones.

The JUGAL is a very stout and somewhat curved bone forming the postero-ventral and ventral boundaries of the orbit. Its anterior end has a deep notch which causes the formation of two sharp tooth-like processes. The jugal articulates with the maxilla in such a way that the ventral tooth overlaps and the dorsal tooth is overlapped by the maxilla. Thus a very strong sutural joint is produced. The posterior end of the bone is triangular and pointed. The postero-dorsal end of the bone is slightly concave due to the presence of a short obliquely vertical process a little in front of the posteriortip. This process fits into a notch in the ventral edge of the postorbital. The facet for the articulation of the postorbital lies a little inner to the postero-dorsal edge of the bone. On the postero-ventral surface articulates the horizontal limb of the squa-



Jugal.
Top, outer view; bottom, inner view.
MX. F., facet for maxilla; *P. ORB. F.*, facet for postorbital; *SQ. F.*, facet for squamosal; *TR. PAL. F.*, facet for transpalatine; *V. P.*, vertical process. [x6.5].

mosal. Thus the posterior tip of the jugal acts as a wedge between the squamosal and the postorbital.

On the inner side of the posterior (obliquely disposed) half of the jugal there is a shallow but large concavity which serves for the attachment of some of the muscles of the lower jaw. In front of this concavity, near the bifid anterior tip of the jugal, there is an articulating surface for the transpalatine (ectopterygoid).

The prefrontal, postorbital and jugal are membrane bones.

c. The Olfactory Capsule

The two olfactory capsules are situated in front of the orbits and are formed mainly of cartilage protected by bones. The greater wall of the olfactory capsule is cartilaginous and unsupported by bone, but at the postero-lateral margin there is a short ingrowth from the prefrontal bone. This part of the prefrontal meets, at its ventral end, a process of the palatine. The posterior half of the side wall of the olfactory capsule is supported by the ascending process of the maxilla. Dorsally the capsule is covered over by the nasal, while ventrally it is supported by the prevomer and the very short prevomerine process of the palatine. The median nasal process (processus nasalis) of the premaxilla and the cartilaginous nasal septum separate the two capsules from each other.

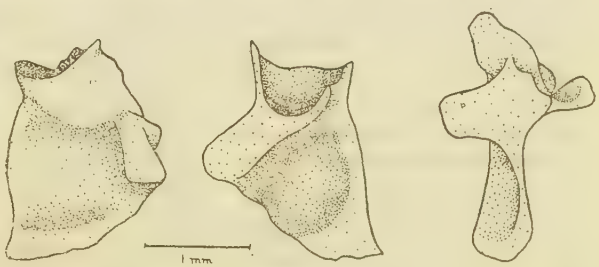
The external nostril leads into the vestibule or the first (anterior) part of the olfactory capsule. The vestibule also extends slightly in front of the external nostril. The vestibule opens behind into the olfactory chamber or the posterior part of the capsule. The chamber extends backwards and somewhat upwards and is almost completely surrounded by cartilage. Posteriorly the side wall of the anterior part of the capsule is seen to be continuous with the inner or mesial wall of the concha nasalis.

The concha nasalis is a sac-like structure opening in front by the auditus conchae. Its cavity, the cavum conchale, lodges the lateral nasal gland. The lateral wall of the concha is rather short, so that the greater part of the nasal gland has no cartilaginous covering on the outside. Behind the postero-lateral wall of each concha, there is a space leading into the cavity of the olfactory chamber. This space represents the cavum extraconchalis, and because of the shortness of the lateral wall of the concha, is not very extensive. In transverse section the cavum extraconchalis can be seen at its widest in the region just posterior to the olfactory chamber. The opening of the latter into the buccal cavity, the fenestra choanalis or basalis, also is situated in this region.

The nasal capsule is separated from the orbit behind by a cartilaginous septum known as the lamina antorbitale or lamina orbitonasalis. Dorsally the lamina meets the nasal septum immediately in front of the two olfactory bulbs, and laterally it is attached in the region of the prefrontal. The lamina antorbitale is uncalcified.

The nasal septum, which separates the two nasal capsules from each other, is a median structure lying just below the the nasal process of the premaxilla and attached posteriorly to the lamina antorbitale. It is not in morphological continuity with the interorbital septum but is separated from it by a non-chondrified or membranous strip. Unlik *Calotes* (Iyer, 1943), *Uromastix* does not have a fenestrated nasal septum. As in the chondrocranium of most lizards (de Beer, 1937), the dorsal edge of the nasal septum passes directly into the roof of the capsule on each side. Anteriorly the nasal septum meets the antero-lateral walls of the olfactory capsules to close them in front. The posterior region of the olfactory capsule is without a floor and ventrally the nasal septum ends bluntly. However, in the anterior part of the capsule, especially in the region of Jacobson's organ, there are horizontal cartilages forming the base of the capsule and supporting Jacobson's organ also. In a transverse section these cartilages are seen to lie ventral to the septomaxillae. They form the lamina transversalis anterior and for a short distance become continuous with the ventral edge of the nasal septum. In this region, therefore, the nasal chamber is completely surrounded by a ring of cartilage, the zona annularis.

On the floor of each olfactory chamber and roofing Jacobson's organ, is a membrane bone, the SEPTOMAXILLARY, called turbinal by Siebenrock (1894). It is situated below the external nostril, on each side of the processus nasalis of the premaxilla, just above the prevomer, almost in the angle between the maxilla and premaxilla. It is not a flat bone as in *Varanus* (Bahl, 1937), *Calotes*, (Iyer, 1943) *Lacerta* and many other lizards (Lapage, 1928), but is a fairly complicated structure. It may be described as consisting of a cupshaped structure with the

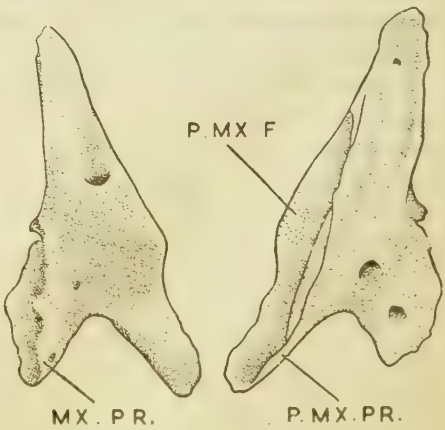


Septomaxillary.
Left, outer view; middle, inner view; right, side view.

concavity directed backwards, a slightly curved, more or less horizontal thin bony plate arising from the base of the cup, and a short blunt process also arising from the dorso-mesial side of the base of the cup. The broad plate forms the roof of Jacobson's organ and is attached in front to the maxilla and mesially to the nasal septum. The blunt process is directed upwards and outwards along the outer wall of the olfactory chamber, between the latter and the nasal gland. Sections through this region show that the blunt process is hollow. In general, the relations of this bone are typical of the Lacertilia and Ophidia (Lapage, *op. cit.*).

The NASALS do not fuse to form a single bone as in *Varanus* (Bahl, 1937) but remain separate as in most lizards. They form the roof of the posterior part of the nasal capsule. Each nasal is a triangular bone with a narrow posterior region and a broad, bifid anterior region. The anterior bifid end of the nasal encloses the posterior dorsal end of the nasal fossa. The dorsal side of the nasal is slightly convex and the ventral correspondingly concave in keeping with the shortness of the face. In most specimens the nasal lies immediately in front of the frontal between its median and antero-lateral processes. The latter process separates the nasal from the prefrontal for a short distance, but never throughout their length as described by Beddard (1905) and in some cases by El-Toubi (1945). Thus for a considerable distance the nasal articulates laterally with the prefrontal. In the region of the nasal fossa, the nasal bifurcates; its narrower limb (premaxillary process) runs for a short distance along the nasal process of the premaxilla, while the other, broader limb (maxillary process) extends ventrad to meet the ascending process of the maxilla. An upward extension of the latter separates this broad limb of the nasal from the prefrontal.

Along the median line the two nasals are in contact with each other for a considerable distance. At their posterior end they are separated by the anterior median process of the frontal and at the anterior end by the processus nasalis of the premaxilla. The degree of their separation anter-



Nasal.

Left, ventral view; right, dorsal view. *MX. PR.*, maxillary process; *P. MX. F.*, facet for premaxilla; *P. MX. PR.*, premaxillary process. [x 8].

iorly and posteriorly shows considerable variation. In most dried skulls of *Uromastix hardwickii*, the processus nasalis of the premaxilla can be seen to extend only very slightly beyond the postero-dorsal end of the nasal fossa. However a longitudinal section through this region shows that a very short conical portion of the premaxilla may be overlapped by the two nasals meeting above it. In a few skulls overlapping is not complete, so that the processus nasalis of the premaxilla can be seen in the dorsal view of the skull to extend considerably between the two nasals, but never separating them completely. The latter condition has, however, been reported in *U. aegyptia* (El-Toubi, 1945). Very rarely (in one specimen out of about 3 dozen studied) the processus nasalis of the premaxilla may extend up to the frontal, but the two nasals meet in the middle and cover the greater part of it. The posterior part of the processus nasalis in this case can be seen in the form of a rhomboid area between the frontal and the posterior border of the nasals. Beddard (1905) who came across a similar rhomboid area in *U. aegyptia*, described it as the dorsal extension of the mesethmoid. Later, El-Toubi (1945) working on the same species recognized the true nature of the rhomboid area as the posterior extension of the processus nasalis of the premaxilla.

In its posterior half each nasal forms a ridge at its junction with the postfrontal. For some distance the antero-lateral process of the frontal also takes part in this ridge. On the inner (mesial) side of the nasal, in the thickness of the bone, there is a facet for the articulation of the processus nasalis of the premaxilla. This facet does not extend to the posterior tip of the nasal and indicates the anterior limit of the processus nasalis. The posterior two thirds of this facet show a concavity into which the processus fits. On the outer side of the unbifurcated portion of the nasal, there is a facet for articulation with the prefrontal and the antero-lateral process of the frontal.

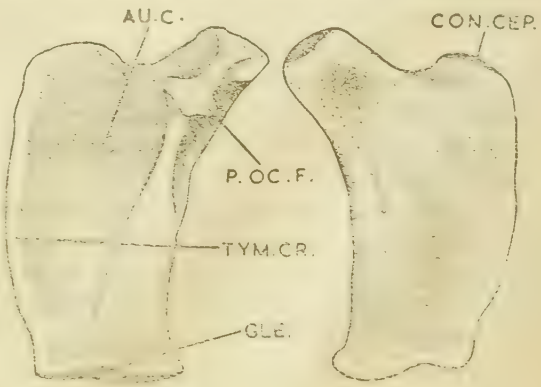
The nasal is perforated by a number of foramina, which are variable in their occurrence and position. One passage or canal, which transmits a blood-vessel, is relatively constant. Its posterior opening is situated in the middle of the ventral face of the nasal, and the anterior opening lies in the angle between the two anterior limbs of the bone.

Jacobson's organs are oval sacs lying in the anterior part of the buccal cavity, in the region of the external nostrils. They are protected by the septomaxilla and extensions of the lamina transversalis anterior. They open by a slit-like opening on each side between the maxilla and the prevomer. The opening of Jacobson's organ is separated from the choana (internal nostril) by a membranous partition into which cartilage may also extend in some cases.

THE SUSPENSORIUM

The term suspensorium denotes a series of bones, cartilages, etc. by means of which the lower jaw is attached to the skull. As commonly understood, the suspensorium includes the quadrate supported and strengthened by the squamosal, the supratemporal (tabular ?) and the paroccipital process of the exoccipital. Another apparently unrelated bone, the epipterygoid or columella cranii is best described here as it also ossifies in the pterygoquadrate cartilage.

The QUADRATE is a pillar-like bone inclined somewhat antero-ventrally as in *Varanus* (Bahl, 1937), *Hemidactylus* (Mahendra, 1940) and Geckos (El-Toubi & Khalil, 1952). Perhaps this is not of much significance because in many other Agamidae, viz., *Calotes* (Iyer, 1943), *Physignathus*, *Chlamydosaurus* and *Amphibolurus* (Beddard, 1905 a), the quadrate is directed backwards. In the quadrate two parts can be recognized, viz., a relatively thick rod-like part on the inner (mesial) side, and a thin broad wing-like plate, the tympanic crest, fused laterally to it. The tympanic crest, whose width seems to bear no fixed proportion with its length, is convex anteriorly and concave posteriorly, the curvature being very prominent near the upper end of the bone. Thus on its posterior side, the quadrate furnishes an auditory cup for the tympanum. At the dorsal end of the mesial rod-like portion of the quadrate there is a condyle covered over by cartilage. This condyle, the condylus cephalicus, articulates above in a deep socket formed at the junction of four bones, viz , squamosal, supratemporal, supratemporal process of the parietal and the paroccipital process of the exoccipital. The greater part of this socket is formed by squamosal and supratemporal, the tip of the latter excluding the processus parietalis completely and the paroccipital process of the exoccipital almost completely. The tip of the paroccipital process of the exoccipital rests on a somewhat concave facet situated outer and posterior to the main



Quadrate.

Left, posterior view; right, anterior view.

AU. C., auditory cup; *CON. CEP.*, condylus cephalicus; *GLE.*, glenoid surface; *P. OC. F.*, facet for paroccipital process; *TYM. CR.*, tympanic crest. [x 8].

condyle. At the base of the two condylar surfaces there is a groove running throughout the length of the rod-like portion of the quadrate. The ventral head of the quadrate (condylus mandibularis) possesses a double condylar surface known as the glenoid surface, for the articulation of the lower jaw. Of these, the condyle on the mesial side is larger than the other. The glenoid surface also is covered over by a very thin sheet of cartilage. Unlike *Varanus* (Bahl, *op. cit.*), many Geckos (El-Toubi & Khalil, *op. cit.*), *Agama* (El-Toubi, 1947) and *Scincus* (El-Toubi, 1938), the pterygoid does not articulate directly with the quadrate but is attached to its inner (mesial) side in the ventral one-third by an elastic ligament. This condition of the pterygoid in *Uromastix hardwickii* was recorded earlier by Saksena (1942).

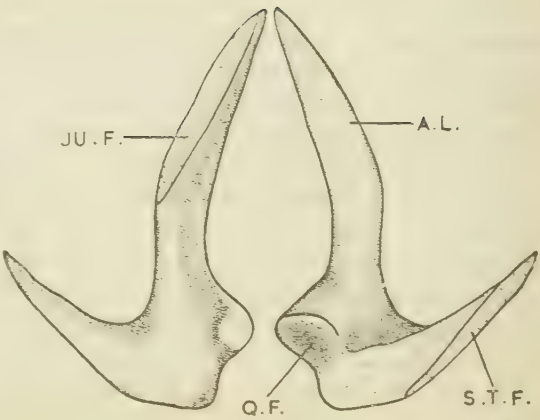
All the joints into which the quadrate enters are movable. This condition, known as streptostylism, is met with in most members of the Lacertilia.

The EPIPTERYGOID or COLUMELLA CRANII is a slender rod of bone disposed obliquely dorso-ventrally, the dorsal end being distinctly posterior. It lies immediately in front of the auditory capsule of its side. Its dorsal end is somewhat compressed from side to side and articulates with the ventral side of the processus parietalis, at a facet situated just external to that for the pro-otic and the antero-lateral process of the supraoccipital. There is no processus descendens of the parietal to articulate with it as there is in *Scincus* (El-Toubi, 1938). The ventral end is somewhat pointed and fits into an oval socket, the fossa columellae, on the dorsal edge of the pterygoid, just above the facet for the basipterygoid process of the basisphenoid. The joints at both ends of the epipterygoid are movable and non-sutural. The epipterygoid ossifies in the processus ascendens of the pterygoquadrate cartilage of the chondrocranium.

The SQUAMOSAL is a roughly V-shaped bone whose apex rests on the quadrate ; one limb articulates with the jugal and the other, abutting against the supratemporal, runs parallel to the processus parietalis. The shorter limb is conical in shape and has a facet along the whole of its outer side (i.e. on the side towards the cranium) which abuts against the supratemporal. The longer limb is sword-shaped and curved in two planes : it is concave on the ventral side and convex dorsally, and also slightly concave on the outer side (away from the cranium) and convex on the inner (mesial) side. In the anterior half of the longer limb, on the dorso-mesial side, there is a facet for articulation with the jugal. It is against the posterior end of this facet that the postorbital sometimes articulates.

At the base of the longer arm of the squamosal there is a concave facet which forms a part of the groove in which the condyle of the quadrate fits. The outer edge of this facet rests on a flat surface between the condyle and the tympanic crest of the quadrate.

The squamosal is a membrane bone.

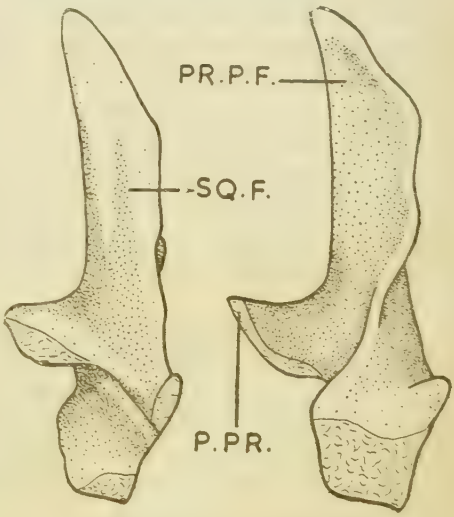


Squamosal.

Left, postero-mesial view ; right, postero-lateral view.

A. L., anterior limb ; *JU. F.*, facet for jugal ; *Q. F.*, facet for quadrate ; *S. T. F.*, facet for supratemporal. [x 8].

The SUPRATEMPORAL (TABULAR?) is a more or less straight bone attached to the supratemporal process of the parietal (processus parietalis) and lying between it and the inner limb of the squamosal. At the outer end of the bone there is a nodule which forms the inner wall of the socket for the condyle of the quadrate. Just in front of the nodule there is a short conical process directed posteriorly and intercalated between the paroccipital process of the exoccipital and the processus parietalis. As a result of this intercalation only the tips of the two processes manage to come in actual contact. The supratemporal in early types, according to Broom (1913), is a membrane bone whose essential function seems to be the support of the parietal on the paroccipital. This function is apparently retained by the supratemporal in *Uromastix hardwickii*. Beyond the posteriorly directed process the



Supratemporal (Tabular ?)

Left, antero-lateral view ; right, postero-lateral view.

P. PR., posterior process ; *PR. P. F.*, facet for processus parietalis ; *SQ. F.*, facet for squamosal.

supratemporal is compressed from side to side and appears to be slightly spirally twisted. This appearance is produced by the fact that the facet for the inner limb of the squamosal begins near the outer end (nodule) and extends upwards. Since the side abutting against the process of the parietal is flat, the facet for squamosal produces differences in the thickness of the bone and thus produces the impression of spiral twisting.

The supratemporal, like squamosal, is a membrane bone.

THE PALATE AND THE UPPER JAW

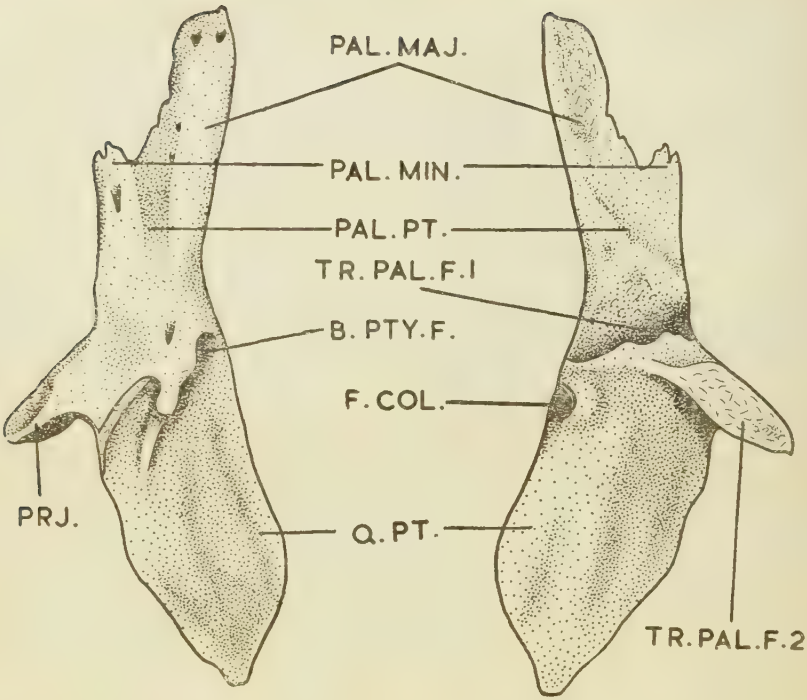
The palate and the upper jaw are formed of the pterygoids, transpalatines (=ectopterygoids -transverse), palatines, prevomer, premaxilla and maxillae. As in other Agamidae, the palate in *Uromastix hardwickii* is completely toothless (Camp, 1923).

The PTERYGOIDS are long bones extending from the quadrate behind almost, but not quite, to the prevomer in front. Near its middle each pterygoid has a short, nearly vertical ridge which bears, on its anterolateral side, a facet for the inner ventral process of the transpalatine. The ventral end of this ridge projects below and, uniting a process of the transpalatine, forms the prominent pterygo-transpalatine projection. Saksena (1942) is wrong in concluding that in *U. hardwickii* the pterygo-transpalatine projection is formed almost exclusively by the transpalatine.

The part of the pterygoid in front of this ridge may be called the palatal part. The dorsal inner process of the transpalatine articulates with the palatal part of the pterygoid at a facet just anterior to the above-mentioned ridge. The palatal part is thick, more or less flat and extends forwards and inwards to a point just posterior to the prevomer. The two pterygoids do not meet in the middle line, nor is there any ligament connecting them. Posteriorly the two pterygoids diverge and enclose, between them and the basisphenoid, a heart-shaped vacuity called the interpterygoid vacuity.

Along the outer side of the palatal part of the pterygoid lies the palatine. Behind the ridge for the transpalatine the pterygoid is very thin, broad, wing-like and obliquely vertical, forming an angle of about 70° with the horizontal plane. This may be called the quadrate process. It extends posteriorly to the quadrate without actually articulating with it, the two being united together by means of a ligament.

At the junction of the two parts of the pterygoid, i.e. at the base of the anterior end of the quadrate process, on the inner side, there is a facet



Pterygoid.

Left, ventral view ; right, dorsal view.

B. PTY. F., facet for basipterygoid process of basisphenoid ; *F. COL.*, fossa columellae ; *PAL., MAJ.*, processus palatinus major ; *PAL. MIN.*, processus palatinus minor ; *PAL. PT.*, palatal part ; *PRJ.*, pterygoid portion of pterygo-transpalatine projection ; *Q. PT.*, quadrate process ; *TR. PAL. F. 1*, facet for inner dorsal process of transpalatine ; *TR. PAL. F. 2*, facet for inner ventral process of transpalatine. [x 7].

for the basipterygoid process of the basisphenoid. As mentioned previously thare is a cartilaginous meniscus pterygoideus between the basipterygoid process and the pterygoid. Saksena (1942), however, seems to have overlooked this meniscus. The facet is not vertical but oblique, its dorsal end being distinctly posterior to its ventral end.

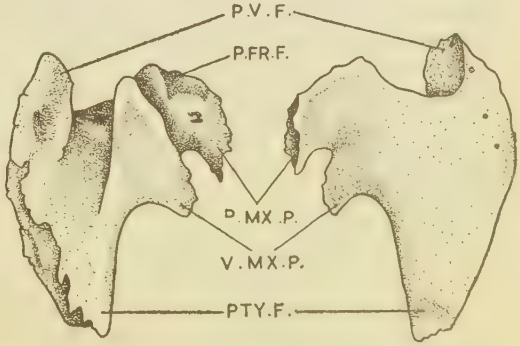
At the base of the quadrate process of the pterygoid, and just posterior to the ridge for the transpalatine, almost at the dorsal edge of the bone but slightly outwards, there is an oval depression, the fossa columellae for the ventral end of the epipterygoid.

The palatal part of the pterygoid is relatively thick and flat. It is thicker at is posterior end than in the anterior region which has been termed

processus palatinus major by Saksena (*op. cit.*). Near the middle of the palatal part, on the outer side, there is a short triangular process, the processus palatinus minor. The relative size of this process varies considerably in different specimens. Half the width of the processus palatinus major, and the whole of the processus palatinus minor, are overlapped by the inner edge of the palatine. The outer edge of the palatal part of the pterygoid is somewhat serrated.

The processus palatinus major extends far forwards so as to reach apparently almost to the posterior end of the prevomer. Beddard (1905) emphasized this close approximation of the two bones in *Uromastix aegyptia* and pointed out the resemblance with *Sphenodon*. Bahl (1937) found that in *Uromastix* the two bones were actually in contact. However, as pointed out by Saksena (1942) and El-Toubi (1945) the processus palatinus major in *Uromastix* does not extend up to the prevomer, and this genus agrees with other Lacertilia in this respect. The process of the pterygoid stops short at the base of the prevomerine process of the palatine, whereas the tip of the prevomer covers only the anterior half of this process. The pterygoid and the prevomer are, thus, distinctly separate from each other, but are joined together by a ligament.

The two PALATINES lie in front of the pterygoids, and together with the prevomer, form the palate. Each palatine is roughly triangular in shape. The apex of the triangle is directed posteriorly and extends up to the transpalatine. The base of the triangle lies anteriorly between the prevomer and the maxilla and forms the posterior border of the olfactory capsule. The inner border of the palatine is serrated and meeting a similar border of the palatal part of the pterygoid forms a strong joint. The two bones do not meet end to end, but the palatine actually overlaps about half the width of the process of the pterygoid. The processus palatinus minor fits into a deep fissure or groove formed



Palatine.
Left, ventral view ; right, dorsal view.

D. MX. P., dorsal maxillary process ; *P. FR. F.*, facet for prefrontal ; *PTY.* F., facet for pterygoid ; *P. V. F.*, prevomerine process ; *V. MX. P.*, ventral maxillary process. [x 7].

near the apex of the triangular palatine, as if by the separation of two layers or strata of the bone.

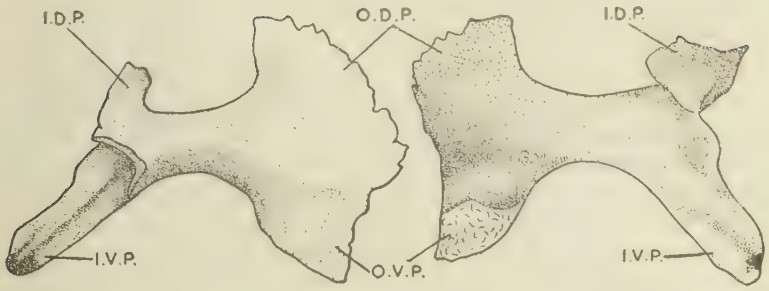
The anterior side of the palatine bears the prevomerine process at its inner side. This process is truncated anteriorly, flattened dorsoventrally and directed slightly obliquely downwards. The posterior tip of the wing-like process of the prevomer abuts against the ventral side of this process.

Along the whole of the outer ventral side of the palatine, there is a ridge. At the anterior end of this ridge there is an oblique process, the ventral maxillary process, whose anterior end is directed downwards and inwards, while the posterior end is directed outwards. On its ventral side this process bears a facet for articulation with the inner side of the maxilla and abuts against the anterior end of the maxillary (outer dorsal) process of the transpalatine. It forms the anterior boundary of the posterior palatal (suborbital) vacuity.

Anterior and dorsal to the ventral maxillary process of the palatine lies the broad, squarish, dorsal maxillary process. There is a deep notch between the posterior ends of the two maxillary processes. On the ventral side of its anterior half the dorsal maxillary process shows a facet for the prefrontal. The outer side of the dorsal maxillary process articulates below with the maxilla in the angle between the latter and the prefrontal, and on the dorso-lateral aspect with the jugal. In other words, the outer side of the dorsal maxillary process meets the upper jaw at the suture between the jugal and the maxilla, and thus articulates with both. The notch between the two maxillary processes is completed on the outside by the maxilla and thus forms the maxillary or palatine foramen through which the branches of the trigeminal nerve, orbital artery and the maxillary vein enter the canalis alveolaris superior of the maxilla. Apart from the processes and the ridge on the outer ventral side, the palatine is very thin and papery and usually translucent in dried skulls. The palatines do not bear any teeth.

The TRANSPALATINE, known also as the TRANSVERSE or ECTOPTERYGOID is a transverse bone forming the posterior border of the posterior palatine vacuity, and connecting the pterygoid with the maxilla and jugal. It forms the middle part of the floor of the orbit. As it gives off processes at both the ends, it is roughly H-shaped when seen in the posterior view of the skull, though the four limbs of the H are neither equal nor in the same plane.

The outer end of the transpalatine gives out two wing-like processes almost at right angles to each other. One of these processes is dorsal,



Transpalatine (Ectopterygoid)

Left, postero-dorsal view ; right, antero-ventral view.

I. D. P., inner dorsal process ; *I. V. P.*, inner ventral process ; *O. D. P.*, outer dorsal process ; *O. V. P.*, outer ventral process. [x 8].

dorso-ventrally compressed and horizontally disposed. It abuts against the inner side of the maxilla, just posterior to the maxillo-palatine shelf of the latter. A small area of the dorsal outer process abuts against the jugal also. Sometimes its anterior tip is notched due to the backward extension of the palatine foramen. The other process at the outer end of the transpalatine is directed ventrally and being flattened from side to side, is squarish in form. At the ventral end of its outer face there is a prominent facet for articulation with the maxilla at its ventral margin just posterior to the last tooth. The ventral edge of the jugal also abuts against the tip of this process. The posterior face of the outer process of the transpalatine is flat, and is directed somewhat inwards, backwards and downwards.

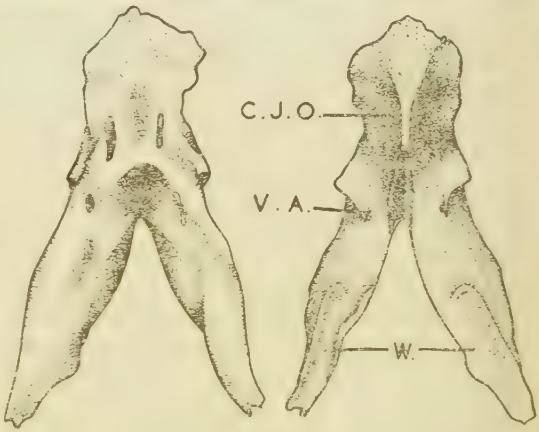
At the inner end of the transpalatine there are again two prcesses, one short, dorso-ventrally flattened, scale-like dorsal process, and a long, narrow, rod-like process directed downwards and somewhat outwards. At the posterior mesial side of the ventral process there is a facet which meets the corresponding facet on a ridge on the outer aspect of the pterygoid. Just anterior to the dorsal edge of this ridge, on the palatal part of the pterygoid, there is an oblique facet for articulation with the inner dorsal process of the transpalatine.

The PREVOMER of *Uromastix hardwickii* has the form typical for the lacertilian skull. It is a thin, apparently unpaired, V-shaped bone whose limbs are directed backwards. The limbs are flattened wing-like structures inclined to each other in such a way as to enclose, in the ventral view, a fairly deep groove. In the anterior region the dorsal edges of the two wings meet to form a prominent ridge which extends almost to the anterior extremity and on which rests the nasal septum. The posterior end of each

wing rests on the ventral surface of the prevomerine process of the corresponding palatine.

In the region just behind the point of union of the dorsal edges of the two wings, there is a peculiar ear-like process, situated near the ventral margin of each wing. Each process takes the from of a plate so disposed that its inner end (by which it is attached to the wing) is situated more posteriorly than the outer end. The plate is concave posteriorly, in some cases moderately, in others deeply. Near the inner margin of the plate, the wing is perforated by the vomerine aperture. Anterior to the plate, the ventral edge of the wing is raised up to become attached to the middle of the plate and thus give rise to a deep concavity. Jacobson's organ lies in this region. As compared to *Varanus*, the prevomer of *Uromastix* is much narrower, and is widely separated from the wide elliptical choanae except at the anterior end. The opening of Jacobson's organ is cut off from the internal nostril only by a membranous partition so that in the dried skull the two openings are continuous. The prevomer is not perforated for Jacobson's organ as in *Varanus* (Bahl, 1937).

The head or the anterior median part of the prevomer is flattened dorso-ventrally and roughly rhomboidal in shape. As in *Uromastix aegyptia* (El-Toubi, 1945) the prevomer does not articulate in front with the premaxilla, but the antero-lateral sides of its head articulate with the anterior inwardly directed processes of the maxilla. In this respect the prevomer of *Uromastix* resembles the prevomer of many geckos (El-Toubi & Khalil, 1952), and differs from that of *Calotes* and *Varanus*.



Prevomer.
Left, ventral view ; right, dorsal view.
C. J. O., concavity for Jacobson's organ ; *V. A.*, vomerine aperture; *W.*, wing-like process.[x10.]

Saksena (1942) who studied the bony palate of three species of *Uromastix*, including *U. hardwickii*, says that the prevomer articulates anteriorly with the premaxilla. This description of the anterior articulation of the prevomer is, no doubt, inaccurate as shown also by the diagrams in Saksena's paper. The lack of articulation of the prevomer with the pre-

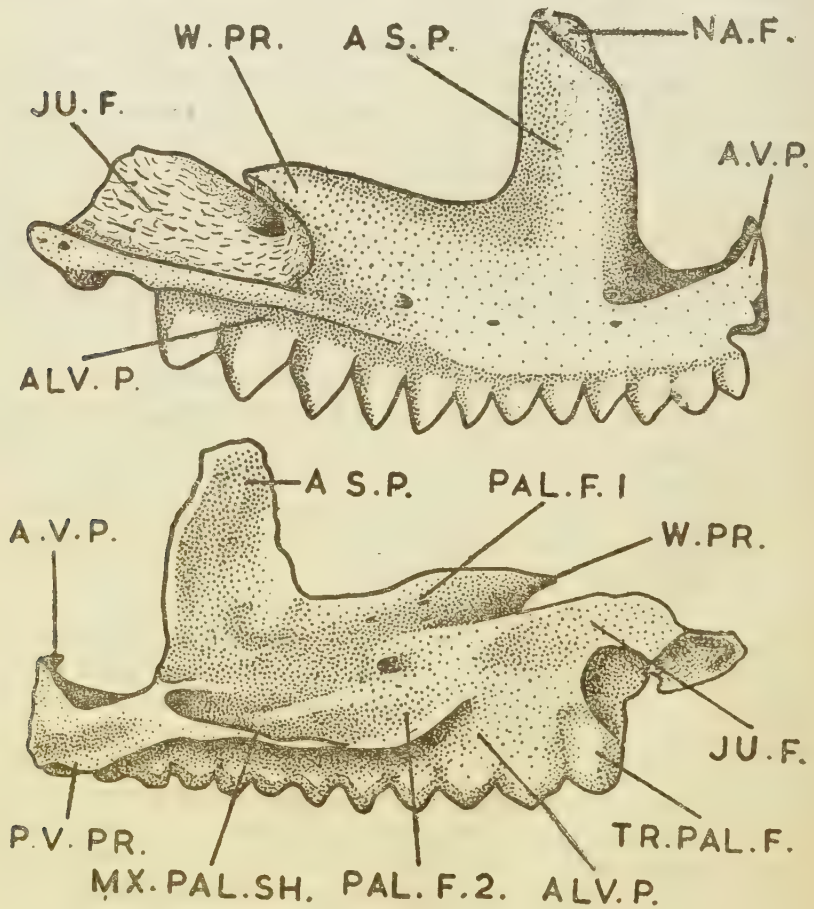
maxilla has been confirmed by cutting longitudinal sections of the skull and by disarticulating the anterior part of the skull bone by bone.

El-Toubi (1945) describes two prevomers in *Uromastix aegyptia*. According to him, "anteriorly the prevomers are in contact with each other, but their posterior parts are separated by a narrow vacuity." Iyer (1943) remarks that "the paired vomers of *Uromastix* (are represented) by the median and unpaired vomer of *Calotes*". Beddard (1905) also speaks of "vomers." However in all the specimens of *Uromastix hardwickii* studied the prevomer was found to be a single median bone with two posteriorly directed wing-like processes. This is in complete accord with the findings of Saksena (*op. cit.*). El-Toubi and Iyer have probably been misled by the paired wing-like processes or by the condition in other Lacertilia, e.g. *Varanus* (Bahl, 1937). It may, however, be mentioned that according to de Beer (1937) "in some forms (Teleostei, Chelonia, Lacertilia, birds, *Ornithorhynchus*) the prevomers in the adult appear to be fused into a single bone, but the development reveals traces of paired origin....."

The name "prevomer" is of relatively modern origin. Many authors, e.g. Beddard (1905), Bahl (1937), and Iyer (1943) continue to call this bone by the older name "vomer". However, it has been established that the reptilian "vomer" is not homologous with the vomer of mammals. In order to differentiate the two, the name "prevomer" has now been accepted for the bone lying in the anterior part of the palate of lower vertebrates.

The paired MAXILLAE are extensive bones forming the greater part of the face in front of the eyes, and lying on each side of the premaxilla. Near its anterior end, each maxilla has a broad, laterally flattened ascending process extending upwards and forming the posterior border of the anterior nasal fossa. Posteriorly, the ascending process meets the prefrontal, and dorsally it is wedged between the latter and the nasal. Immediately behind the ascending process and continuous with it, there is a low, vertical, laterally compressed ridge ending behind in a wedge-like process. Behind the ridge the greater portion of the upper part of the maxilla is overlapped by the jugal whose anterior ventral process abuts against an oblique facet on the posterior part of the jugal just below the wedge-like process. The dorsal (inner) process of the jugal abuts against almost the whole of the inner side of the ridge of maxilla, so that the maxillary ridge is wedged between the two processes of the jugal. The alveolar portion and a ridge separating it from the facet for the jugal remain uncovered and can be seen on the outside.

At the posterior end of the maxilla, at the tip of the ridge below the facet for the jugal, there is a facet directed downwards and inwards. The outer ventral process of the transpalatine abuts against it. The outer dorsal process of the same bone articulates with a narrow antero-posteriorly elongated facet on the inner side of the maxilla, just above its alveolar part.



Maxilla.

Top, outer view ; bottom, inner view.

ALV. P., alveolar portion ; *AS. P.*, ascending process ; *A. V. P.*, anterior vertical process ; *JU. F.*, facet for jugal ; *MX. PAL. SH* , maxillo-palatine shelf: *NA. F.*, facet for nasal ; *PAL. F.* 1, facet for dorsal maxillary process of palatine ; *PAL. F.* 2, facet for ventral maxillary process of palatine ; *P. V. PR.*, prevomerine process ; *TR. PAL. F.*, facet for transpalatine ; *W. PR.*, wedge-like process. [x 9].

At the anterior tip of the maxilla there are two short, narrow, dorsally pointed, vertical processes, one continuous with the outer edge of the maxilla and the other in continuation with the short, horizontal prevomerine process of the maxilla. The two processes are separated from each other, except ventrally by a deep groove. The inner process is connected also with the base of the ascending process. The short maxillary ridges of the premaxilla fit into the groove between the two anterior processes of the maxillae. Between the base of the anterior vertical process and the alveolar region there is a notch which, in a complete skull, becomes a foramen bounded anteriorly by the premaxilla. It opens behind on to the ventral side of the palatal plate of the maxilla, but does not seem to transmit anything as it is closed by a membrane in the living condition.

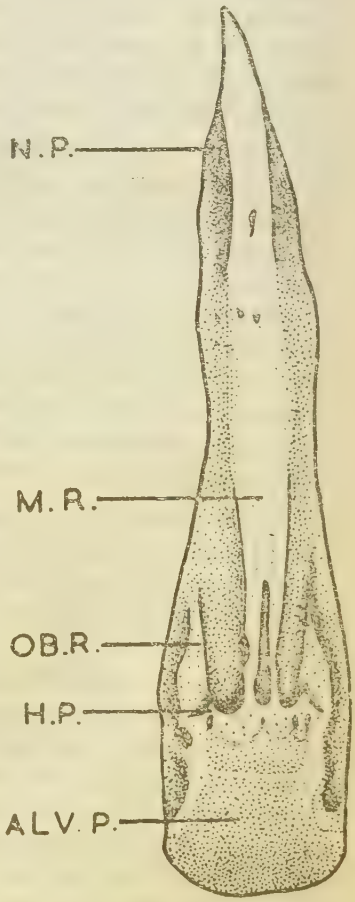
On the inner face of the maxilla, just above the alveolar part, there is a narrow, horizontal, maxillo-palatine shelf. The posterior, relatively broader part of this shelf is overlapped by the ventral maxillary process of the palatine. The dorsal maxillary process of the palatine abuts against the inner side of the maxilla at an oblique facet just posterior to the base of the ascending process. At the anterior end of the shelf, on the dorsal side, there is a foramen which perforates the base of the ascending process and opens into the groove running from the ascending process to the two anterior processes. The blood vessel entering the olfactory chamber through the orbitonasal canal travels along the dorsal side of the maxillo-palatine shelf and eventually emerges through the above-mentioned foramen.

A transverse section shows that the alveolar portion of the maxilla is traversed by a canal lodging the maxillary artery and the superior alveolar nerve. Two to four small maxillary foramina along the middle of the outer surface of the maxilla serve to transmit the branches of the nerve to the skin.

There are usually fifteen hollow acrodont teeth in each maxilla. The anterior 7 or 8 teeth are smaller than the rest and in older specimens get worn off, so that a "diastema" is formed between the "incisor" teeth on the premaxilla and the posterior "molars". Apart from the difference in size between the anterior and posterior maxillary teeth, there is no apparent differentiation in the teeth of *Uromastix hardwickii*. The same is true of the teeth in the lower jaw. According to Smith (1935) also, there are no proper canines in the genus *Uromastix*, and incisors and grinders are the only types of teeth present. The crowns of the maxillary teeth are directed downwards and inwards. Transverse sections of the maxilla show that the teeth are not mere outgrowths of the bone but are formed of a substance (dentine ?) laid down in layers.

The PREMAXILLA is a single median bone formed by the complete fusion of the premaxillae of the two sides. This is in complete accord with the condition in other members of the Agamidae (Smith, 1935). It is a narrow bone lying at the anterior end of the snout between the two maxillae. It consists of two portions : an antero-posteriorly compressed alveolar portion bearing teeth, and a laterally compressed nasal process (processus nasalis). The alveolar portion bears four distinct but very small "incisors" in young specimens, but in older forms the teeth get worn off and the alveolar portion of the premaxilla assumes a spatula-like form. The processus nasalis extends upwards and backwards, forming the mesial boundary of the two nasal fossae, and serving as a wedge between the two nasals. In a few cases the posterior tip of the nasal process is slightly bifid and may be interpreted as giving the clue to the paired nature of the premaxilla. Variations with regard to its extent backwards have already been described above in connexion with the nasals.

Externally the premaxilla is smooth. On the inner side it bears a number of ridges and processes. In the anterior ventral half there is a median ridge in continuation with the ventral edge of the laterally compressed nasal process, but not extending to the tip. This ridge serves for the attachment of the nasal septum. Flanking the ventral end of the median ridge on each side there is an oblique, antero-laterally directed ridge which fits into the groove between the two anterior processes of the maxilla. From the base of each oblique ridge there arises a small scale-like horizontal process which underlies the palatal process of the maxilla. The prevomer and the septomaxillaries do not reach the premaxilla in front.



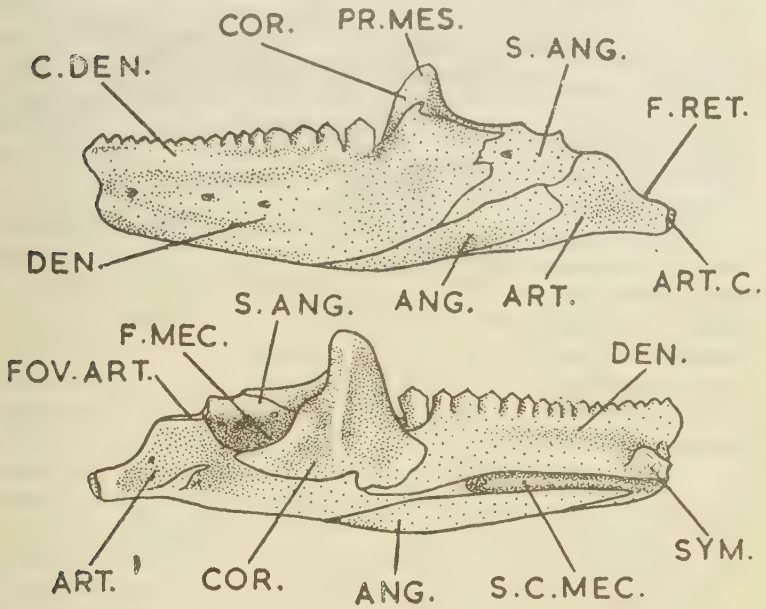
Inner view of premaxilla.

ALV. P., alveolar portion ; *H. P.*, horizontal process ; *M. R.*, median ridge ; *N. P.*, nasal process; *OB. R.*, oblique ridge. [x13].

THE LOWER JAW

The lower jaw consists of two rami united together at the anterior end through a bony symphysis. In *Uromastix hardwickii* each ramus comprises five bones developed in relation to the persistent Meckel's cartilage. The bones are (1) articular, with which the prearticular has fused; (2) angular; (3) supra-angular; (4) coronoid and (5) dentary.

The ARTICULAR (with the prearticular fused with it) is an elongated



Lower jaw.

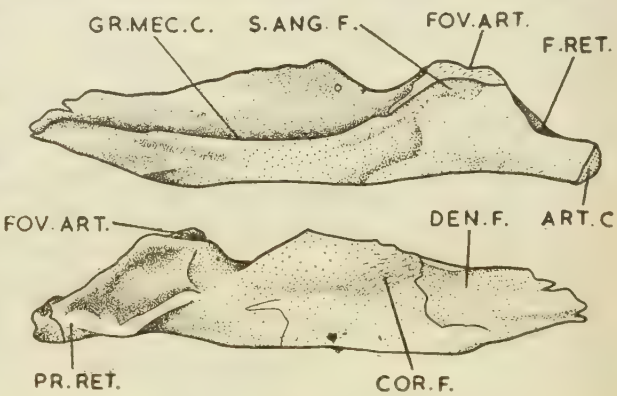
Top, outer view; bottom, inner view.

ANG., angular; *ART.*, articular; *ART. C.*, articular cartilage; *C. DEN.*, crista dentalis; *COR.*, coronoid; *DEN.*, dentary; *F. MEC.*, fossa Meckelii; *FOV. ART.*, fovea articularis; *F. RET.*, fossa retroarticularis; *PR. MES.*, processus messetericus; *S. ANG.*, supra-angular; *S. C. MEC.*, sulcus cartilaginis Meckelii; *SYM.*, tuberosity for symphysis. [x 4].

bone forming the posterior part of the mandible and extending considerably far forwards. Its posterior or proximal end is thick and strong and bears, on its dorsal side, an oval transversely elongated concave facet, the fovea articularis, for articulation with the ventral end of the quadrate. The part of the bone behind the fovea is conical and narrows down suddenly. It is known as the postarticular process (processus retroarticularis)

and is tipped by a small articular cartilage. The dorsal surface of the postarticular process is concave and constitutes the fossa retroarticularis. Its outer dorsal edge serves for the attachment of the ventral border of the tympanic membrane.

The anterior part of the articular is thin and more or less vertical. Looked at from the dorsal side, this part of the articular appears like an open drain pipe, the inner wall of which is higher than the outer and is slightly sinuous. Along this drain pipe runs Meckel's cartilage. On the outer face of the disarticulated articular there is a facet for the angular, starting just in front of the fovea articularis and extending in front to the pointed tip of the bone. On the inner face of the anterior part of the articular there is an extensive facet where the dentary abuts against it. The posterior dorsal part of this facet is overlapped by the coronoid. On the inner side of the posterior region of the articular there is a very prominent concavity, extending posteriorly to the tip of the processus retroarticularis, and bounded ventrally by a prominent flattened ridge. Near the upper margin of this concavity, just below the fovea articularis, there is a minute aperture for the chorda tympani nerve. On the dorsal side, immediately in front of the fovea articularis and behind the groove for Meckel's cartilage, there is a facet for the supra-angular.



Articular.

Top, outer view; bottom, inner view.

ART. C., articular cartilage; *COR. F.*, facet for coronoid; *DEN. F.*, facet for dentary; *FOV. ART.*, fovea articularis; *F. RET.*, fossa retroarticularis; *GR. MEC. C.*, groove for Meckel's cartilage; *PR. RET.*, processus retroarticularis; *S. ANG. F.*, facet for supra-angular. [x 6].

The articular is the only cartilage bone in the lower jaw.

The ANGULAR forms a considerable part of the ventral border of the mandible. In the outer view of the mandible it appears as a splint-like bone near the lower border, lying below the supra-angular and in front of the processus retro-articularis. A little in front it comes to lie on the

ventral side. Its anterior one third is overlapped by the dentary and can be seen only on the inner side.

A disarticulated angular shows that its posterior portion, which abuts against the articular, is compressed from side to side and very thin. The anterior three fourths or more looks like the blade of a knife, thick ventrally and thin dorsally. Since the thinning is not gradual, a ledge is formed on the inner side of the bone. This ledge forms the floor of the canal for Meckel's cartilage. Anteriorly the angular becomes very thin and narrows down to a point.

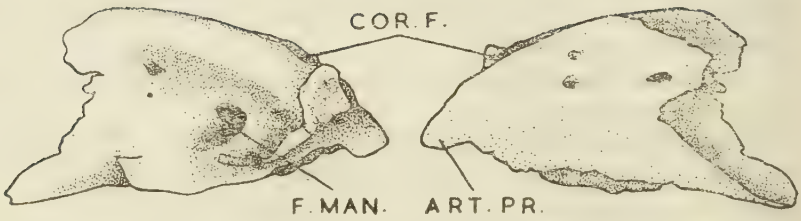
Inner view of angular.

ART. F., facet for articular; *GR. MEC. C.*, groove for Meckel's cartilage. [x 4.5].

The SUPRA-ANGULAR is an irregularly shaped bone lying in front of the fovea articularis and behind the coronoid. In the side view of the mandible it is seen to be a triangular bone with the processus retroarticularis behind, angular below and dentary in front. Looked at in the inner view of the mandible, the supra-angular is seen to form the outer wall of a large antero-posteriorly elongated oval fossa, the fossa Meckelii, lodging the nerves and blood vessels of the lower jaw, and Meckel's cartilage. This fossa is bounded in front by the coronoid, ventrally by the angular and posteriorly by the articular.

The disarticulated supra-angular is a roughly triangular bone with its apex directed posteriorly. It is thick at the apex and along the dorsal side, but comparatively thin ventrally and at the base. On the postero-ventral aspect of the inner side, there is a short ledge which makes the concavity of the inner face very prominent. A small conical process from the outer side of the thick apex runs along the outer border of the fovea articularis, and may be called the articular process. Along the thickness of the dorsal side there is a facet for the supra-angular process of the coronoid. There is no coronoid process. At the base (anterior side) of the triangle, the bone shows two edges or layers between which the postero-dorsal edge of the dentary fits.

The supra-angular is perforated by a number of foramina. The most important is a large foramen on the inner concave face of the bone near its posterior end. This foramen is usually oval, but may be reniform or round. There is some variation in its size also. Through this foramen a branch of the mandibularis (V) nerve enters a canal lying in the thickness of the bone and sends out branches to the skin on the outer surface by two or three foramina. The position of some of these foramina is variable. The

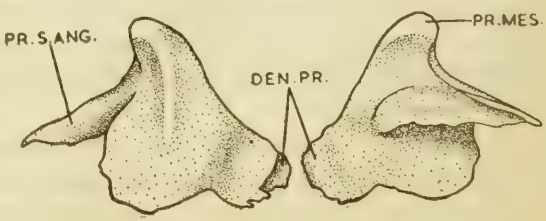


Supra-angular.
Left, inner view; right, outer view.
ART. PR., articular process; *COR. F.*, facet for supra-angular process of coronoid; *F. MAN.*, foramen for mandibularis nerve. [x 6.5].

one least variable in position lies at the anterior end of the bone, almost in the middle of the base of the triangular supra-angular, just posterior to its sutural joint with the coronoid. Another foramen usually lies just behind the foramen mentioned above, or it may lie in the middle of the bone, almost opposite the main foramen on the inner side. In some specimens another foramen may be found near, but slightly ventral to it. A foramen on the inner face of the supra-angular, near its posterior dorsal edge, also leads into the same canal.

In addition to the above-mentioned foramina, there may be additional openings on the inner face of the supra-angular near the anterior edge, near the main foramen, or even in the thickness of the bone at the anterior end where it is joined to the dentary.

The CORONOID is a triangular, laterally compressed bone the apex of which projects upwards into the lateral temporal fossa to form the processus messetericus just behind and external to the prominent ventral process of the pterygoid and transpalatine. It articulates behind with the supra-angular, ventrally with the articular and in front with the dentary. On the outer side of the bone there arises, in the upper half of the anterior border, a backwardly directed triangular process, the supra-angular process, which is thick at the base but thin distally (posteriorly). Thus the apex of the triangular coronoid becomes very thick. This process rests on the dorsal edge of the supra-angular

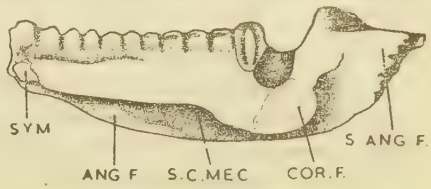


Coronoid.
Left, inner view; right, outer view.
DEN. PR., process overlapping a part of dentary; *PR. MES.*, processus messetericus; *PR. S. ANG.*, supra-angular process. [x 4].

and the supra-angular process of the dentary, and constitutes the outer dorsal border of the fossa Meckelii. The inner edge of this fossa is formed by the coronoid proper. A notch in the ventral border of the coronoid separates an anterior squarish process from the remainder. The squarish process overlaps the posterior part of a flat, plate-like, vertical projection on the inner side of the dentary. In the angle between the coronoid proper and its triangular process, i.e. in the anterior wall of the fossa Meckelii, there are two minute apertures for blood vessels etc. In some specimens additional foramina may be present in the same region or on the outer face of the bone. The adductor muscles of the lower jaw are attached to the coronoid.

The DENTARY is by far the largest among the five bones of the lower jaw and constitutes the main part of the distal half of the mandible. At its postero-dorsal edge there is a wedge-like process which fits into the corresponding region of the supra-angular. The posterior part of the inner surface of the dentary is covered over by the coronoid, while the angular covers the greater part of its ventral border. In the posterior half, there is a large, semi-circular, laterally compressed, plate-like process projecting inwards, at a slight angle, from the upper region of the dentary. The posterior half of this plate is overlapped by the coronoid. The space between the process and the dentary proper is a part of the large canal beginning at the anterior end of the fossa Meckelii and lodging the mandibular nerve, artery and vein as well as Meckel's cartilage. In the region of attachment of the anterior wall of the plate-like process to the dentary, there is a large elliptic foramen leading into a canal lying just below the row of teeth. The inferior alveolar nerve and the blood vessels lie in this canal. In front of the plate-like process of the dentary, Meckel's cartilage comes to lie in a groove, the sulcus cartilaginis Meckelii, which opens out mesially. The lower wall of this groove is formed by the angular.

At the anterior end of the dentary, on the mesial side, there is a tuberosity just above the sulcus cartilaginis Meckelii. It is at this tuberosity that the dentaries are united with each other. The sulcus of each dentary bends inwards to lie on the ventral side of the tuberosity, so that below the mandibular symphysis the two Meckel's cartilages also



Inner view of dentary.

ANG. F., facet for angular ; *COR. F.*, facet for coronoid ; *S. ANG F.*, facet for supra-angular ; *S.C. MEC.*, sulcus cartilaginis Meckelii ; *SYM.*, tuberosity for symphysis. [x 5.5].

unite. This is a character found in the chondrocranium of many Lacertilia (de Beer, 1937).

On the outer face of the dentary, along the middle of its width, there are usually four small foramina in a row, for the exit of blood capillaries.

The teeth are acrodont and lie on the crista dentalis or the upper border of the dentary. In young specimens there are usually 14 teeth in each dentary, but in older specimens the anterior 4 or 5 teeth become worn off. The anterior dorsal tips of the two dentaries bite against the incisor-like premaxilla. The teeth are hollow and supplied with blood vessels.

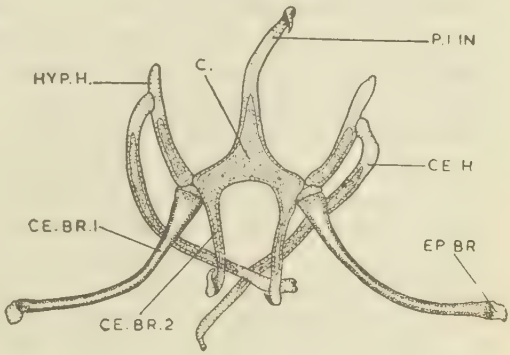
Apart from the five bones described above, El-Toubi (1945) has described a sixth bone, the splenial, in the lower jaw of *Uromastix ægyptia*. A small splenial has also been sketched by Sedgwick (1905) between the coronoid and dentary on the inner side of the mandible of *Uromastix*. In *U. hardwickii*, however, a splenial is absent and the mandible is formed of five bones only. This condition is not unusual. El-Toubi (*op. cit.*) quotes Camp (1923) as stating that the splenial is small or absent in the Agamidæ. This, however, is not a hard and fast rule ; a splenial is absent in *Agama stellio* (El-Toubi, 1947) but present in *Calotes versicolor* (Iyer, 1943) though both the lizards belong to the same family. A comparison of the mandible of *Uromastix hardwickii* with the figures given by Sedgwick and El-Toubi shows that the uncovered part of the inner plate-like process of the dentary is a distinct bone in the species studied by these authors. However, all available methods of examination, e.g. under the microscope or by separating the bones by boiling in a solution of KOH, have failed to reveal a distinct splenial in this species.

THE HYOID APPARATUS

The hyoid apparatus is composed of the ventral constituent of the hyoid arch and the first two branchial arches. It consists of a curved transverse plate, the corpus, produced in front into the long median processus entoglossus (processus lingualis) which supports the tongue. Fused to the postero-lateral ends of the corpus are two slender rods, the ceratobranchials of the second arch, lying on either side of the trachea. Articulating with the ends of the corpus are two long processes or cornua. The anterior cornu (cornu hyale) is two-jointed ; the proximal segment, the hypohyal (?), is long and antero-laterally directed, while the distal segment, the ceratohyal, is directed postero-laterally. The two segments are

joined end to end, but the proximal end of the ceratohyal articulates in a socket near the distal end of the hypohyal (?).

The second cornu (cornu branchiale I) is directed postero-laterally, is formed by the first branchial arch, and consists of two segments. The proximal, somewhat curved segment, which is formed by the ceratobranchial, is bony as in most lizards, and articulates with the end of the corpus by a ball and socket joint. This is the longest single piece in the hyoid apparatus. The distal segment of this cornu is formed of a narrow, moderately long cartilage representing the epibranchial.



Hyoid apparatus.

C., corpus ; *CE. H.*, ceratohyal ; *CE. BR. 1*, ceratobranchial of the first branchial arch ; *CE. BR. 2*, ceratobranchial of second branchial arch; *EP. BR.*, epibranchial ; *HYP. H.*, hypohyal (?) ; *P. LIN.*, processus lingualis. [x 4].

Apart from the bony ceratobranchial (I) and the epibranchial formed of hyaline cartilage, the various parts of the hyoid apparatus are formed of calcified cartilage.

THE TEMPORAL FOSSAE AND OTHER VACUITIES IN THE SKULL

There is a single lateral temporal fossa in the skull of *Uromastix*. According to the terminology used by Goodrich (1930), and in fact the majority of workers in this field, it is the superior temporal fossa corresponding to the upper fossa in the skull of *Sphenodon* or a crocodile.

The superior temporal fossa is an oval opening just behind the orbit. It is bounded mesially by the processus parietalis ; posteriorly by the processus parietalis, supratemporal and squamosal ; anteriorly by the postorbital ; and ventrally by the superior temporal arcade formed by the processes of postorbital and squamosal, with the jugal forming its ventral part.

The gap below the superior temporal fossa, i.e. between the jugal and the quadrate, may be regarded as the inferior temporal fossa which opens below due to the absence of a quadratojugal. In a typical diapsid skull the quadratojugal and a process of the jugal form the inferior tem-

poral arcade connected posteriorly with the quadrate and bounding the inferior temporal fossa below.

The posterior temporal fossae are two oval spaces seen in the posterior view of the skull. Each posterior temporal fossa, called the foramen retrotemporal by Siebenrock (1894), is bounded above and on the outer side by the processus parietalis, ventrally by the exoccipital and mesially by the supraoccipital.

Another interpretation of the bones at the posterior end of the superior temporal fossa is offered by Watson (1914). He regards the V-shaped bone, which articulates in front with the jugal, as the quadratojugal, and gives the name of squamosal to the inner bone next to the processus prietalis. This interpretation emanates from his view that the Lacertilia have evolved not from a diapsid reptile but from a parapsid reptile like *Araeoscelis* or *Pleurosaurus*. However, as mentioned above, the majority of workers do not contribute to this view.

On the ventral side of the skull, in the posterior region, there is a quadrangular cavity on each side, bounded externally by the quadrate and the quadrate process of the pterygoid, and internally by the basisphenoid, pro-otic and paroccipital process of the exoccipital. This is the cavity of the middle ear, and the columella auris runs across it.

Between the palatal parts of the two pterygoids, and bisected by the parasphenoid, there is a median heart-shaped vacuity, the interpterygoid vacuity.

Below each orbit, and bounded in front and on the inner side by palatine, posteriorly by the ectopterygoid and externally by the maxilla, there is an oval vacuity known as the suborbital or posterior palatine vacuity.

At the anterior end, between the prevomer and the maxilla, there is an elongated aperture, the choana. At its anterior end a small foramen, the opening of Jacobson's organ, is cut off by a membranous flap. The rest of the choana serves as the internal nostril. In many lizards, including *Varanus*, the internal nostril is completely cut off from the opening of Jacobson's organ.

STREPTOSTYLISM AND KINETISM

In *Uromastix* the quadrate is freely movable. At its upper end it articulates movably with the squamosal and supratemporal above and the paroccipital process of the exoccipital behind, while at the lower end it is attached to the quadrate process of the pterygoid by a ligament. The epipterygoid (columella cranii) is also isolated from it as only a ligament

runs between the two. A skull in which the quadrate is movable relative to the neighbouring bones, is termed streptostylic (Stannius, 1856), in contrast with a monimostylic skull in which the quadrate is immovably fused with the squamosal.

Streptostylism is a noteworthy phenomenon because it indicates the degree of attachment of a part of the ossified pterygoquadrate to the osteocranium. It was shown by Versluys (1910, 1912) that the important factor in the classification of the relations between the upper jaw and the osteocranium was not the movability of the quadrate by itself but of the upper jaw as a whole (*sensu lato*) relatively to the brain box. He showed that even in a monimostylic skull, like that of *Sphenodon*, the maxillary segment, i.e. the upper jaw and the associated bones (quadrate, squamosal, quadratojugal if present, jugal, maxilla, premaxilla, pterygoid, transpalatine, palatine, prevomer, nasal, frontal and parietal) may move as a whole relatively to the occipital segment (basioccipital, exoccipitals, supraoccipital, pro-otic, opisthotic, basisphenoid, and parasphenoid). The points of contact between the two segments are : between paroccipital process of the exoccipital and the quadrate ; between the basipterygoid process of the basisphenoid and the pterygoid ; and between supraoccipital and the undersurface of the parietal. A skull possessing this type of mobility is called kinetic.

It has been shown that streptostylism and kinetism, though often occurring together, are independent phenomena and a streptostylic skull may be akinetic as in Mammalia. The skull of *Uromastix* and, in fact, of most Lacertilia, is both streptostylic and kinetic.

Dilating on the kinetism of the lacertilian skull, Goodrich (1930) remarks that "in such forms as *Tupinambis* and *Uromastix* a bending of the roof becomes possible in front of the orbit." He called this type of skull mesokinetic and as a further example mentioned that "Parrots have a markedly mesokinetic joint allowing the upper beak to be raised." He contrasted this type of skull with the metakinetic type in which "the interorbital septum is weakly developed and partly membranous while the posterior brain case is only loosely joined to the parietals." Thus the skull of *Sphenodon*, whose kinetism has been detailed above, is precisely of the metakinetic type, and so are the skulls of *Calotes* and *Varanus*.

The skull of *Uromastix hardwickii* fails to show any movement of the roof in front of the orbit relatively to the posterior part. On the other hand it shows pronounced characteristics of a metakinetic joint, viz., the hinge in the roof of the skull lies between the supraoccipital and pro-otic

on one hand and the parietal on the other. The latter is not joined rigidly to the occipital segment.

Iyer (1943) has interpreted Goodrich's (1930) remarks about *Uromastix* and *Tupinambis* as meaning that "a bending of the roof becomes possible even between the parietal and frontal." This interpretation of the term "mesokinetic" is obviously fallaceous because the fronto-parietal joint is not "in front of the orbit" as it should be according to definition. Secondly in his diagram (Fig. 464) of the kinetic skull of the Dinosaur *Creosaurus*, Goodrich has again shown the mesokinetic joint in front of the orbit and not between frontal and parietal.

It may be added that a mesokinetic joint, as understood by Iyer, would involve movement between frontal and parietal, between pterygoid and palatine, between palatine and prevomer and between transpalatine and maxilla. In the skull of *Uromastix* the joints between these pairs of bones are not movable. It may, therefore, be concluded that the bony skull of *Uromastix* like those of *Sphenodon*, *Varanus* and *Calotes*, is of the metakinetic type.

SUMMARY

1. The skull of *Uromastix hardwickii* Gray is well-ossified though there are several important cartilaginous and membranous areas.

2. The occipital condyle is distinctly tripartite.

3. The tuberculum spheno-occipital is reduced to a very thin sheet of cartilage.

4. The supraoccipital is movably articulated with the parietal. Processus ascendens tecti is a bony process tipped with cartilage.

5. The parietal and frontal are unpaired bones. The pineal fossa does not pierce the parietal but lies between the parietal and the frontal.

6. The frontal does not form a bony canalis olfactorius. Its antero-lateral process does not separate the nasal and the prefrontal completely.

7. The interorbital septum is partly membranous and partly cartilaginous. The planum supraseptale and its extensions have also been described.

8. The cavum capsularis together with the columella auris and the passages for the semicircular canals have been described in detail.

9. There is no lachrymal, supraorbital, postfrontal or quadratojugal. The superior temporal arcade is complete.

10. The olfactory capsule and the bones protecting or supporting it have been described. The septomaxillary is not a flat plate-like bone, but

is fairly complicated. The nasals are separate but in contact with each other medially.

11. The pterygoid extends far forwards but does not meet the prevomer. Together with the transpalatine it forms a prominent downwardly directed process.

12. The prevomer is unpaired and does not articulate with the premaxilla.

13. Maxillae bear acrodont, heterodont teeth, but distinct canine teeth are not seen even in young specimens.

14. The premaxilla is unpaired and bears incisor teeth which may get worn off in older specimens.

15. The skull is typically metakinetic and streptostylic.

16. Each ramus of the lower jaw consists of 5 bones ; there is no splenial. The two rami are united at a bony symphysis. Remnants of Meckel's cartilage also meet in front.

17. The hyoid apparatus is formed by the hyoid and the first two branchial arches. The ceratobranchial of the first branchial arch is bony.

REFERENCES

Bahl, K. N., 1937. Skull of *Varanus monitor* (Linn.). Rec. Ind. Mus., **93** : 133-174.

Beddard, F. E., 1905. Some notes on the cranial osteology of the Mastigure lizard, *Uromastix*. Proc. zool. Soc. Lond., 2-9.

———, 1905 a. A contribution to the anatomy of the frilled lizard (*Chlamydosaurus kingi*) and some other Agamidae. Proc. zool. Soc. Lond., 9-22.

de Beer, G. R., 1937. *The development of the vertebrate skull.* Oxford.

Broom, R., 1913. On the squamosal and related bones in the Mosasaurs and lizards. Bull. Amer. Mus. Nat. Hist., **32** : 507-508.

———, 1922. On the persistence of the mesopterygoid in certain reptilian skulls. Proc. zool. Soc. Lond., 455-460.

Busch, C. H., 1898. Beitrage zur Kenntniss der Gaumenbildung den Reptilien. Zool. Jb. (Anat.), **11** : 441-99.

Camp, C. L., 1923. Classification of the lizards. Bull. Amer. Mus. Nat. Hist., **48** (11) : 288-435.

El-Toubi, M. R., 1938. The osteology of the lizard *Scincus scincus*. Bull. Fac. Sci. Cairo, No. 14, 1-38.

———, 1945. Notes on the cranial osteology of *Uromastyx aegyptia* (Forskal). Bull. Fac. Sci. Cairo, No. 25, 1-10.

———, 1947. Some observations on the osteology of the lizard, *Agama stellio* (Linn.). J. Morph., **81** (2) : 135-150.

El-Toubi, M. R. & Khalil, A., 1952. The cranial osteology of Egyptian geckos. Bull. de l'inst. Fouad I du Desert, **2** (2) : 84-110.

Gegenbaur, C., 1898. *Vergleichende Anatomie der Wirbeltiere.* Leipzig.

Goodrich, E. S., 1930. *Studies on the structure and development of Vertebrates.* London.

Guenther, A., 1867. Contribution to the anatomy of Hatteria (*Rhynchocephalus*, Owen). Phil. Trans., **167** : 595-629.

Iyer, M. M. N., 1943. The habits, external features and skeletal system of *Calotes versicolor* (Daud.). Part II. The skull. J. Mysore Univ. B., **4** (7) : 115-151.

Kingsley, J. S., 1925. *The vertebrate skeleton.* London.

Lapage, E. O., 1928. The septomaxillary of the Amphibia Anura and of the Reptilia II. J. Morph., **46** : 299-430.

Mahendra, B. C., 1949. The skull of the Indian house-gecko *Hemidactylus flaviviridis* Ruppel. Proc. zool. Soc. Bengal, **2** (1) : 29-42.

Saksena, R. D., 1942. The bony palate of *Uromastix* Merrem. Proc. Ind. Acad. Sci. Bangalore B, **16** (4) 107-119.

Sedgwick, A., 1905. *A student's text-book of Zoology.* London.

Siebenrock, F., 1894. Das Skelet der *Lacerta simonyi*, Steind., und der Lacertidenfamilie ueberhaupt. S. B. Akad. Wiss. Wien, **103** : 205-292.

———, 1895. Das Skelet der Agamiden. S. B. Akad. Wiss. Wien, **104** : 1089-1196.

Smith, M. A., 1935. *The Fauna of British India. Reptilia and Amphibia*, II : *Sauria.* London.

Stannius, H., 1856. *Handbuch der Anatomie der Wirbeltiere.* Berlin. (Quoted by be Beer, 1937).

Versluys, J., 1910. Ueber Streptostylie bei Dinosaurien, nebst Bemerkungen ueber die Verwandtschaft der Vogel und Dinosaurien. Zool. Jb. (Anat.), **30** : 175-260.

———, 1912. Das Streptostylie-Problem und die bewegungen im Schadel bei Sauropsiden. Zool. Jb. (Suppl.), **15** (2) : 545-716.

Watson, D. M. S., 1914. *Pleurosaurus* and the homologies of the bones of the temporal region of the lizard's skull. Ann. Mag. nat. Hist., **14** : 84-95.

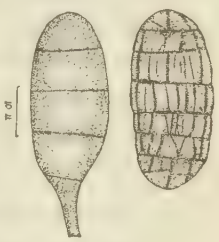
Six new Deuteromycetes from West Pakistan

SULTAN AHMAD

Department of Botany, Government College, Lahore.

***Dichomera macrospora* sp. nov.**

Stroma ellipsoidea vel globosa, innata, 460-550 μ diam., parietibus crassis pars interior (16-20 μ crassa) composita cellulis irregulariter anguliribus, pars exterior (60-80 μ crassa) densa, formata cellulis minutissimis; conidia ellipsoidea vel oblonga, fusca vel quasi nigra, septis transversis 5, in longitudinem numerosis, 27-40 x 16-20 μ; conidiophoris 12-30 x 5-7 μ; pseudophyses nullis.



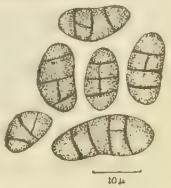
Dichomera macrospora.

On dead branches of *Berberis lycium* Royle, Murree, July 12, 1950, no. 13018, type.

Differs from other species described for *Berberis* spp. in the septation and size of the conidia.

***Dichomera gymnosporia* sp. nov.**

Pycnidia aggregata in 2-5, innata, ellipsoidea vel subglobosa, circumdata hyphis numerosissimis, 235-465 x 230-310 μ, pariete cellulis angulato compressis composito, 12-16 μ crasso; conidia subfusca, ellipsoidea nonumquam curvata, transverse 3-septata, ad septum non constricta, partibus interioribus longitudinaliter septatis, 12-22 x 7-8.5 μ; pseudophyses numerosis.

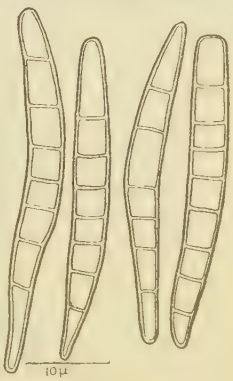


Dichomera gymnosporia.

On dead branches of *Gymnosporia Royleana* Wall., Swat: Barikot, April 19, 1954, no. 9099, type.

***Hendersonia astericola* sp. nov.**

Pycnidia dispersa, primum innata, demum erumpentia, nigra, 190-200 x 250-270 μ, pariete 15μ crasso, composito cellulis angularibus, parvis; conidia olivaceo-fusca, clavata, pars apicalis fastigata, recta vel curvata, 3-vel 8-septata, 32-47 x 3-5 μ.

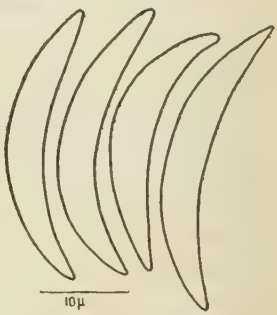


Hendersonia astericola.

On dead branches of *Aster bellidioides* Ham., Swat: Mingora, April 11, 1954, no. 10,004, type.

***Vermicularia arthraxonis* sp. nov.**

Acervulus globosus vel oblongus, niger, ornatus setis carbonaceo-fuscis 75-125 μ longis, ad partem basale 5-7 μ crassis, septatis, rigidus, cylindricis, tunicis crassis, in partibus apicalibus fastigatis ; conidia hyalina, fusoidea, curvata, 28-35 x 4-6 μ.



Vermicularia arthraxonis.

On living leaves of *Arthraxon serrulatus* Hochst., Swat : Madian, August 25, 1952, no. 4780, type.

***Septoria alhagiae* sp. nov.**

Maculis nullis, infectis foliis flavescentibus; pycnidia amphigenis, numerosis, nigro, 125-175 μ diam., ostiolis suborbicularibus, 25-30 μ, erumpentis ; conidia cylindriceis, attenuata ad apicem, rectis vel vermiformibus, hyalinis, 1-septatis, in cirrum protrusis, 30-40 x 2.5-3 μ,

On living leaves of *Alhagi maurorum* Linn., Bahawalpur : Pallah, July 18, 1948, no. 1938, type.

***Leptothyrium gleditschiae* sp. nov.**

Pycnidium dimidiatum, hemisphaericum, dispersum, 214 x 112 μ, pariete crasso, 10-13 μ, composita cellulis compressis ; conidia ellipsoidea, hyalina, unseptata, 16 x 5-7 μ.

On spines of *Gleditschia triacanthos* Linn., Lahore, Feb. 28, 1954, no. 9023, type.

Studies on *Gollaniella pusilla* Stephani

MUHAMMAD ASHRAF KHAN

Department of Botany, Government College, Lyallpur.

The genus *Gollaniella*, with *G. pusilla* as the type species, was described by Stephani (1905) from Mussoorie, India. Kashyap (1915) pointed out that Stephani's genus *Gollaniella* was merely a synonym of the genus *Athalamia* Falconer. Recently Shimizu & Hattori (1953) have reiterated that *Gollaniella* was a valid genus and could easily be distinguished from *Athalamia* as follows :

Plants small and thin ; pores not stellate ; involucres 1 or 2 (seldom 3) per receptacle.....*Gollaniella*

Plants large and thick ; pores usually stellate ; ventral scales conspicuous ; involucres 2-5 per receptacle.....*Athalamia*

Gollaniella pusilla is fairly widely distributed in North-West Himalayas but no work has yet been done on its development. In July-September, 1954, the author found this plant growing in large numbers on the Eastern slopes in Kaghan Valley, Murree and Dunga Gali. The specimens were fixed in chrom-acetic acid, Bouin's Fluid and formol-acetic acid. The sections were cut 4-8 μ thick and stained with iron haematoxylin or Delafield's haematoxylin.

Morphology of the gametophyte : The gametophyte consists of a thin, light green, dorsiventral thallus which may be simple or divided once or twice. It is up to 15 mm. long and about 1.5 mm. broad. Sometimes a number of innovations may occur on the ventral side. The thallus lobes are broad, linear to obovate and notched at the apex. The thallus is 5-10 cells thick in the region of the midrib, but gradually thins out on either side towards the margin. The margins are wavy, purplish, ascending and thin. There is often a median groove on the dorsal surface near the apex. The main body of the thallus consists of a lower compact parenchymatous region and a single layer of air chambers above it. The compact ventral tissue is greenish and bears both smooth and tuberculated rhizoids, and a few scattered scales. The scales are delicate, hyaline or reddish in colour, without appendages and lanceolate in outline. The plant is monoecious, the antheridia usually occurring behind the female receptacle, but sometimes in front of it. The female receptacle is situated on the dorsal surface

and is surrounded by scales. The receptacle tissue is totally wanting. The mature receptacle has one, two, or very rarely five involucres.

Development of the antheridium : The antheridial initial divides by a transverse wall into a basal stalk cell and an apical antheridial cell. The antheridial cell further divides transversely to form a row of four cells in each of which two vertical walls are formed at right angles to each other. After the vertical walls, periclinal walls are laid down differentiating the wall of the antheridium from the primary spermatogenous cells. The basal stalk cell divides by a few transverse and vertical walls to form a short stalk. The division of the primary spermatogenous cells is irregular. The wall of the mature antheridium consists of a single layer of cells. Each antheridium at maturity lies in a chamber which opens on the dorsal side of the thallus by a large hyaline papilla.

Development of the archegonium : An archegonium originates from a single cell the archegonium initial possessing a large deeply staining nucleus. The archegonium initial divides by a transverse wall into a basal and an apical cell. The apical cell has dense granular contents. It divides by three periclinal walls to form a primary axial cell and three peripheral cells. The axial cell divides further by a transverse wall into a lower central cell and an upper cap cell. The central cell then divides by a transverse wall into an upper primary neck canal cell and a lower ventral cell. The primary neck canal cell divides into two and then four neck canal cells, while the primary ventral cell divides transversely to produce a ventral canal cell and an egg. In the meanwhile the cap cell divides by vertical walls to produce six cells at the apex of the archegonium.

Development of the sporogonium : The fertilized egg grows in size and then divides by a transverse wall giving rise to nearly equal epibasal and hypobasal cell. The two cells now divide simultaneously by longitudinal walls to produce four cells, the quadrants. Each quadrant divides further by a longitudinal wall at right angles to the first, and thus a young embryo, formed of eight nearly equal cells, is produced. Anticlinal and periclinal walls now make their appearance in the cells of the embryo and produce a globular mass of cells. Anticlinal walls are formed first, but in the succeeding cell divisions no definite order could be observed. The embryo attaches itself to the tissue of the receptacle. The growth now becomes unequal : it is slow in the middle region but very active in the lower attached and the upper free portions. The former becomes bulbous and is called the foot. The middle narrow portion which subsequently bacomes elongated forms the seta, and is about 1-1.5 mm. in length. The upper region in which the

cells become large and rich in contents, grows rapidly and becomes differentiated as the capsule. In the interior of the capsule two types of cells become differentiated, viz., the globular sporogenous and the elongated elater-like cells. At first the sporogenous cells are amoeboid but later on they divide to produce tetrads. The ripe spores are brown, 45-50μ in diameter and bear numerous high papillae on the surface. The mature elaters are bispiral, brown and 140-180 μ long. The ripe capsule is oval, with a single-layered wall. The wall cells are provided with annular and spiral bands.

REFERENCES

Kashyap, S. R., 1915. Morphological and biological notes on new and little-known West Himalayan liverworts, III. New phyt., 14 : 1-18

Shimizu, D. & Hattori, S., 1953. Marchantiales of Japan. J. Hattori Lab., **9** : 32-44.

Stephani, F., 1905. *Gollaniella pusilla*. Hedwigia, **44** : 74.

Termites of West Pakistan

MUZAFFER AHMAD

Department of Zoology, University of the Panjab, Lahore.

Introduction

This paper is based on the material collected from different parts of West Pakistan mostly during the last seven years. It deals with 30 species, of which eight are new to science.

Desneux (1906) was the first author to report upon termites of West Pakistan. He described *Anacanthotermes macrocephalus*, *Microtermes mycophagus*, *Microtermes sindensis* and *Amitermes belli*, all from Karachi. Holmgren, K. & N. (1917) described *Capritermes punjabensis* from Lyallpur, and recorded *Odontotermes bangalorensis* Holmgren from Lyallpur, and *Odontotermes obesus* (Rambur) from Kasur (District Lahore) and Lyallpur. No further termites were recorded from West Pakistan until Khan & Ahmad (1954) recorded 14 species from Lahore, of which seven species, viz., *Coptotermes heimi* (Wasmann), *Heterotermes indicola* (Wasmann), *Kalotermes beesoni* Gardner, *Odontotermes dehraduni* (Snyder), *Odontotermes gurdaspurensis* Holmgren, K. & N. (reported as a form of *Odontotermes obesus*), *Microcerotermes heimi* Wasmann (mentioned under the name of *Microcerotermes tenuignathus* Holmgren) and *Eremotermes paradoxalis* Holmgren, were new records for West Pakistan. Chaudhry (1954, 1955) added three more described species to the fauna—*Archotermopsis wroughtoni* (Desneux), *Odontotermes parvidens* Holmgren, K. & N., and *Odontotermes almorensis* (Snyder). All these species are included in the present report.

The type specimens are in the author's collection; paratypes are deposited in the Emerson Collection of the American Museum of Natural History, New York.

I am thankful to my post-graduate students Messrs. Muhammad Saleem, Muhammad Aslam Khan, Syed Ishfaq Hussain, Muhammad Anwar Malik, Nasir A. Bashir and Fazle Majid Khan for collecting much of the material on which this paper is based.

My thanks are also due to Dr Alfred E. Emerson of the University of Chicago for confirming the identification of some of the new species.

Measurements and Terms

The first tooth of the imago-worker mandible is designated as the apical tooth and the rest as the marginal teeth which, in primitive mandibles like those of *Archotermopsis*, are further distinguished as the first, second,

and third marginal teeth (Emerson, 1933; Ahmad, 1950). The two sides of a marginal tooth are referred to as anterior and posterior cutting edges. The small tooth at the base of the anterior cutting edge of the first marginal tooth of the right mandible as seen in *Archotermopsis* and the rhinotermitids is called subsidiary tooth.

The length of the head of soldier includes the extended mandibles.

The length of the head up to side base of mandibles represents the greatest length of the head capsule along the lateral side.

The width of the head of the imago includes the eyes.

The diameter of the eye does not include the ocular suture.

The length of the postmentum is the median length of the sclerotized portion.

The width of the postmentum is the greatest width.

The length of the pronotum is the distance between the anterior and posterior emarginations along the median line.

Systematic Account

KEY TO THE FAMILIES

IMAGOES

1. Fontanelle absent 2
   Fontanelle present 3
2. Ocelli present; cerci 2-jointed ... ... Kalotermitidae
   Ocelli absent; cerci 5-8 jointed ... ... Hodotermitidae
3. Left mandible with three marginal teeth; right mandible with a subsidiary tooth... ... ... Rhinotermitidae
   Left mandible with one or two marginal teeth; right mandible without subsidiary tooth ... ... Termitidae

SOLDIERS

1. Head without fontanelle or frontal gland; eyes present, as long as the scape of antenna 2
   Head with fontanelle and frontal gland; eyes if present dot-like, much smaller than the scape of antenna 3
2. Antenna with 23 or more articles; ... ...Hodotermitidae
   Antenna with fewer articles; pronotum large ... ... Kalotermitidae
3. Pronotum flat ... ...Rhinotermitidae
   Pronotum saddle-shaped... ... ... Termitidae

Family KALOTERMITIDAE

Genus *Kalotermes* Hagen

1. *Kalotermes beesoni* Gardner

Kalotermes beesoni Gardner, 1944, p. 103 (soldier). Snyder, 1949, p. 13. Khan & Ahmad, 1955, p. 28 (imago).

IMAGO (Fig. 1) : Head reddish brown ; mandibles dark brown ; postclypeus brown ; labrum and pronotum slightly lighter than the head. Head with a few scattered long bristles and short hairs ; labrum with a few long bristles and short hairs in the anterior half ; pronotum with scattered bristles and short hairs. Head almost round. Eye large, not quite round, anterior margin straight, about half its long diameter from the lower margin of the head. Ocellus large, oval, touching the eye obliquely. Antenna with 16-18 articles, the second nearly twice as long as the third, the fourth slightly shorter than the third. Anteclypeus trapezoid, more than twice as broad as long. The left mandible with two approximated marginal teeth, the first marginal tooth directed anteriorly, the second marginal tooth directed posteriorly. The right mandible with the second marginal tooth broadly rounded, anterior cutting edge short, posterior edge elongated. Pronotum broader than long, antero-lateral corners broadly curved, anterior margin shallowly con-

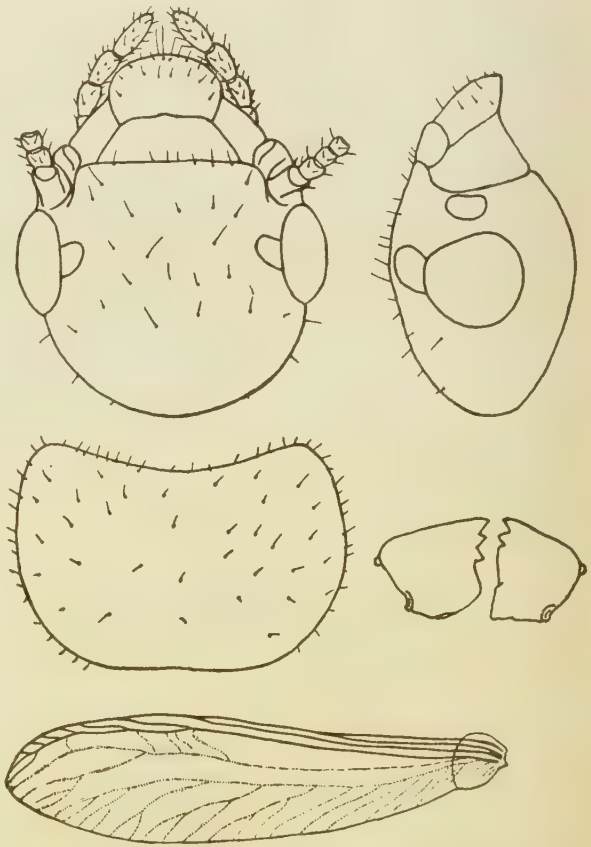


Fig. 1. *Kalotermes beesoni* Gardner, imago: Dorsal view of head and pronotum; side view of head ; mandibles; and forewing.

cave, posterior margin almost straight, with a slight depression in the middle. The scales of forewings large, overlapping the hind wing scales. Forewings with the median running half-way between the cubitus and the radius sector.

TABLE 1

Measurements (in mm.) of the imago of *Kalotermes beesoni* Gardner

	No.	Range	Mean
Length of head to tip of labrum	16	1.51-1.81	1.67
Length of head to side base of mandibles	18	1.18-1.56	1.31
Width of head	19	1.36-1.51	1.48
Long diameter of eye	19	0.48-0.59	0.52
Length of ocellus	19	0.18-0.25	0.22
Width of ocellus	19	0.14-0.20	0.16
Length of pronotum	19	0.68-0.79	0.73
Width of pronotum	19	1.55-1.66	1.59

SOLDIER (Fig. 2) : Head dark reddish brown, slightly lighter posteriorly ; mandibles almost black except at the base ; labrum and terminal articles of antenna light reddish brown ; eyes lightly pigmented ; rest of the body brownish yellow to light brown. Head with a few scattered bristles and short hairs ; postmentum with a few short hairs anteriorly; tip of labrum with 6 to 8 long bristles. Head elongate, frons gradually sloping, sides almost parallel. Eye oval, as long as the scape of the antenna. Postmentum twice as wide in front as in the middle. Antenna with 11 to 14 articles, the third long, clavate, as long as the fourth and fifth combined, the second half as long as the third. Labrum wider than long, antero-lateral sides broadly curved. Mandibles long, stout, with prominent basal hump ; left mandible with three and right mandible with two marginal

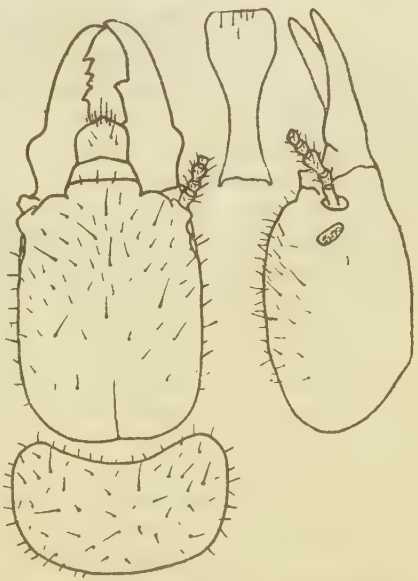


Fig. 2. *Kalotermes beesoni* Gardner, soldier : Dorsal view of head and pronotum; ventral view of postmentum ; and side view of head.

teeth. Pronotum slightly wider than the head, shallowly concave anteriorly, antero-lateral corners broadly curved, posterior side not emarginate.

TABLE 2

Measurements (in mm.) of the soldier of *Kalotermes beesoni* Gardner

	No.	Range	Mean
Length of head with mandibles	28	3.15-4.01	3.61
Length of head to side base of mandibles	29	2.02-2.47	2.24
Width of head	29	1.57-1.95	1.78
Length of postmentum	28	1.12-1.60	1.45
Width of postmentum	29	0.52-0.75	0.64
Length of pronotum	29	0.86-1.12	0.99
Width of pronotum	29	1.91-2.29	1.96

DISTRIBUTION : Lahore, imagoes, soldiers, nymphs, coll. M. A. Khan and M. Ahmad, 10.8.1952. Mianwali, soldiers, nymphs, ex *Zizyphus jujuba*, coll. N. A. Bashir, 7.11.1954. Bhakkar (District Mianwali), soldiers, nymphs, ex *Acacia arabica*, coll. N. A. Bashir, 9.11.1954.

Genus ***Neotermes*** Holmgren

2. ***Neotermes pishinensis*** n. sp.

SOLDIER (Fig. 3) : Head light reddish brown, slightly darker anteriorly ; mandibles dark reddish brown at the base, almost black in outer three-fourths; eyes white; pronotum brownish yellow, legs and abdomen pale. Head sparsely hairy ; postmentum with three long bristles and a few short hairs in the anterior half; tip of labrum with a few long bristles; pronotum with a few scattered short hairs. Head elongate, sides slightly converging anteriorly, one-and-a-half times as long as broad, frons gradually sloping anteriorly. Eye oval, nearly as long as the scape of the antenna. Postmentum twice as wide in front as in the middle, narrowest a little posterior to the middle. Antenna with 16 articles, the third article one-and-a-half times the length of the

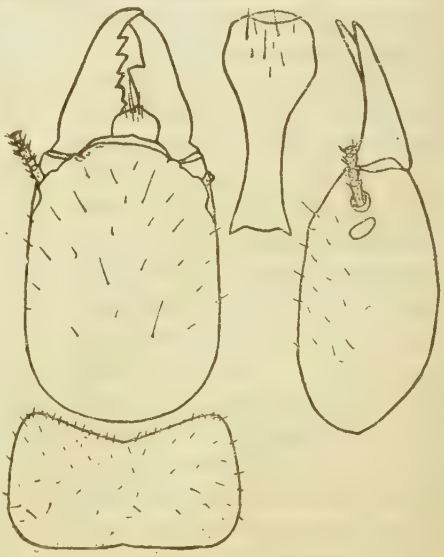


Fig. 8. *Neotermes pishinensis* n. sp., soldier : Dorsal view of head and pronotum ; ventral view of postmentum ; and side view of head.

fourth, the second slightly shorter than the third. Labrum wider than long, antero-lateral sides broadly curved, lateral sides almost parallel. Mandibles long, stout, not extraordinarily broad at base; left mandible with three marginal teeth, molar bilobed; right mandible with two widely separated marginal teeth. Pronotum slightly wider than the head, anterior margin shallowly concave, antero-lateral corners narrowly curved, posterior margin almost straight.

TABLE 3

Measurements (in mm.) of the soldier of *Neotermes pishinensis* n. sp.

	No.	Range	Mean
Length of head with mandibles	7	3.14-3.44	3.28
Length of head to side base of mandibles	7	2.11-2.25	2.18
Width of head	7	1.41-1.62	1.53
Length of postmentum	6	1.48-1.66	1.53
Width of postmentum	7	0.70-0.78	0.74
Length of pronotum	7	0.83-1.04	0.94
Width of pronotum	7	1.72-1.81	1.76

REMARKS: As it is difficult to distinguish soldiers of *Kalotermes* from those of *Neotermes*, the new species is placed under *Neotermes* on the basis of venation of the wing pads of the nymphs in which there is an indication that the median is closer to the radius sector than to the cubitus, a condition typical of the wing venation of *Neotermes*. The new species can be distinguished from all other species of the genus hitherto known from the Indo-Malayan region by its much smaller size.

Described from seven soldiers (holotype, paratypes) and nymphs ex living willow tree, Pishin (District Quetta-Pishin), collected by M. A. Malik, 26.8.1955.

Family **HODOTERMITIDAE**

KEY TO THE GENERA

IMAGOES

Left mandible with three well-developed marginal teeth; right mandible with a distinct subsidiary tooth; tarsi 5-jointed ... ...*Archotermopsis* (Desneux)

Right mandible with only two marginal teeth, third marginal indistinct; tarsi 4-jointed . . . *Anacanthotermes* Jacobson

SOLDIERS

Tarsi 5-jointed; tibiae with lateral spines ... ... *Archotermopsis*

Tarsi 4-jointed; tibiae without lateral spines ... ...*Anacanthotermes*

Genus *Archotermopsis* (Desneux)

3. *Archotermopsis wroughtoni* (Desneux)

Termopsis (Archotermopsis) Wroughtoni Desneux, 1904, p. 445 (imago, soldier).
Termopsis radcliffei Radcliffe, 1904, p. 412.
Archotermopsis Wroughtoni Holmgren, 1911, p. 36 (imago, soldier). Holmgren, 1913b, p. 31 (imago, soldier). Snyder, 1949, p. 55 (synonymy).

IMAGO (Fig. 4) : Head reddish brown; mandibles dark reddish brown, teeth black ; labrum, antennae and pronotum light yellowish brown ; wings hyaline, veins pale. Head with a few scattered minute hairs ; labrum with a row of moderately long bristles at the tip, and short hairs in the middle ; pronotum slightly more pubescent than the head. Head almost round, slightly produced behind in the middle. Eye large, bulging, kidney-shaped, separated from the lower margin of head by about one-fourth of its long diameter. Ocellus absent. Antenna with 23 to 27 articles ; the second one-and-a-half times as long as the third, the fourth slightly longer than the third. Anteclypeus trapezoid. Mandibles with primitive dentition ; left mandible with three marginal teeth ; right mandible with two marginal teeth, a subsidiary tooth at the base of the anterior cutting edge of the first marginal tooth. Pronotum halfmoon-shaped, slightly emarginate anteriorly, almost straight posteriorly.

Fig. 4. *Archotermopsis wroughtoni* (Desneux), imago : Dorsal view of head and pronotum ; side view of head ; and mandibles.

TABLE 4

Measurements (in mm.) of the imago of *Archotermopsis wroughtoni* (Desneux)

	No.	Range	Mean
Length of head to tip of labrum	8	2.63-2.96	2.75
Length of head to side base of mandibles	8	1.96-2.40	2.17
Width of head	8	2.33-2.70	2.49

	No.	Range	Mean
Length of eye	8	0.85-1.04	0.93
Width of eye	8	0.69-0.77	0.74
Eye from lower margin of head	8	0.18-0.22	0.20
Length of pronotum	8	0.96-1.22	1.10
Width of pronotum	8	1.89-2.22	2.04

SOLDIER (Fig. 5): Head light reddish brown, slightly darker anteriorly; mandibles reddish brown; labrum pale; anteclypeus white; eyes black; pronotum slightly lighter than the head. Head with a few scattered minute hairs; labrum with a few bristles at the tip; pronotum with very short scattered hairs. Head longer than broad, trilobed posteriorly, sides converging anteriorly. Eye spindle-shaped, slightly shorter than the scape of the antenna. Postmentum elongate, flat. Antenna with 23 to 26 articles, the second slightly longer than the third, the fourth longer than the third. Anteclypeus trapezoid. Mandibles long, stout, with prominent marginal teeth. Pronotum flat, nearly one-and-a-half times as wide as long, anterior margin convex, not emarginate, posterior margin almost straight.

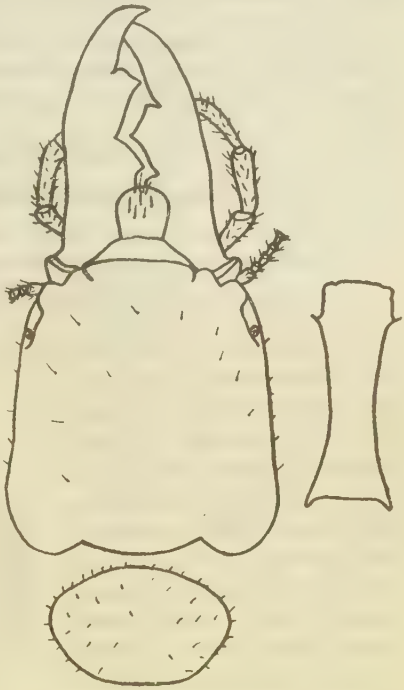


Fig. 5. *Archotermopsis wroughtoni* (Desneux), soldier: Dorsal view of head and pronotum; and ventral view of postmentum.

TABLE 5

Measurements (in mm.) of the soldier of *Archotermopsis wroughtoni* (Desneux)

	No.	Range	Mean
Length of head with mandibles	15	6.37-7.00	6.89
Length of head to side base of mandibles	15	3.85-4.06	3.94
Width of head	15	3.57-3.85	3.69
Length of postmentum	12	2.52-2.94	2.79
Width of postmentum	15	1.05-1.12	1.10
Length of pronotum	15	1.47-1.54	1.49
Width of pronotum	15	2.38-2.66	2.51

DISTRIBUTION : Dunga Gali (District Hazara), imagoes, soldiers, nymphs, ex dead Pine tree, coll. T. B. Fletcher, 25.5.1915. Naran, (7898 ft.) in Kaghan Valley (District Hazara), one imago, at light, coll. M. Ahmad, 26.8.1950. Chhangla Gali (District Hazara), soldiers, nymphs, ex Pine tree, coll. M. Saleem, April, 1951. Shogran (8200 ft.) in Kaghan Valley (District Hazara), soldiers and nymphs, ex logs and stumps of *Pinus excelsa*, coll. Ghulamullah, 17.9.1953. Lun Bagla (District Muzaffarabad, Azad Kashmir), soldiers and nymphs, ex *Pinus excelsa*, coll. M. A. Khan, 6.9.1955. Chakar (District Muzaffarabad, Azad Kashmir), soldiers, nymphs, ex *Pinus excelsa*, coll. M. A. Khan, 8 9.1955.

Genus ***Anacanthotermes*** Jacobson

4. ***Anacanthotermes macrocephalus*** (Desneux)

Hodotermes macrocephalus Desneux, 1906, p 344 (imago, soldier, worker).
Hodotermes (Anacanthotermes) macrocephalus Holmgren, 1911, p. 43 (soldier). Holmgren, 1913 b, p. 25 (imago, soldier).
Anacanthotermes macrocephalus Snyder, 1949, p. 62 (synonymy).

IMAGO (Fig. 6) : Head, antennae and labrum brownish yellow ; pronotum darker than the head ; meso-and metanota of the same colour as pronotum. Head with long bristles, more numerous on lateral sides ; labrum with long bristles ; pronotum with scattered long bristles around the edges ; tergites sparsely hairy. Head round, antero-lateral corners prominent. Eye rather small, not bulging, anterior margin straight, separated from the lower margin of the head by slightly more than its long diameter. Ocellus absent. Antennae with 26 to 29 articles, the second as long as the third and fourth combined, the fourth slightly longer than the third. Labrum slightly wider than long, anterior margin straight, antero-lateral sides broadly curved. The left mandible with widely separated first and third marginal teeth, the second marginal tooth rudimentary, the right mandible with an indistinct subsidiary tooth.

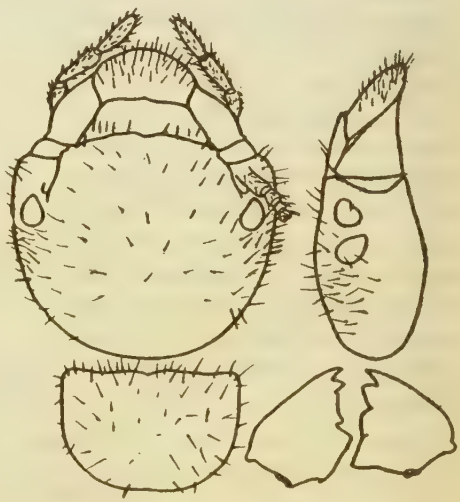


Fig. 6. *Anacanthotermes macrocephalus* (Desneux), imago : Dorsal view of head and pronotum ; side view of head ; and mandibles.

Pronotum raised anteriorly, anterior margin indistinctly emarginate, anterolateral corners narrowly curved, sides almost parallel, posterior margin almost straight.

TABLE 6

Measurements (in mm.) of the imago of *Anacanthotermes macrocephalus* (Desneux)

	No.	Range	Mean
Length of head to tip of labrum	10	3.44-3.70	3.57
Length of head to side base of mandibles	10	2.41-2.66	2.56
Width of head	10	2.96-3.18	3.08
Length of eye	10	0.48-0.52	0.50
Width of eye	10	0.32-0.37	0.34
Eye from lower margin of head	10	0.55-0.62	0.58
Length of pronotum	10	1.41-1 55	1.47
Width of pronotum	10	2.22-2.41	2.29

MAJOR SOLDIER (Fig. 7): Head reddish brown, gradually becoming darker anteriorly; mandibles, except the basal third, almost black; eyes black; pronotum yellowish brown; legs and abdomen pale. Head with a few scattered short hairs; postmentum with a few long bristles and short hairs in the anterior two-thirds; pronotum sparsely hairy. Head only slightly narrowed anteriorly. Eye broadly oval, nearly as long as the scape of the antenna. Postmentum narrowed posteriorly. Antenna with 29 articles, the second longer than the third, the fourth and the third subequal. Anteclypeus trapezoid. Labrum broader than long, anterior margin shallowly concave. Mandible large, stout, with well-developed marginal teeth. Pronotum halfmoon-shaped, an-

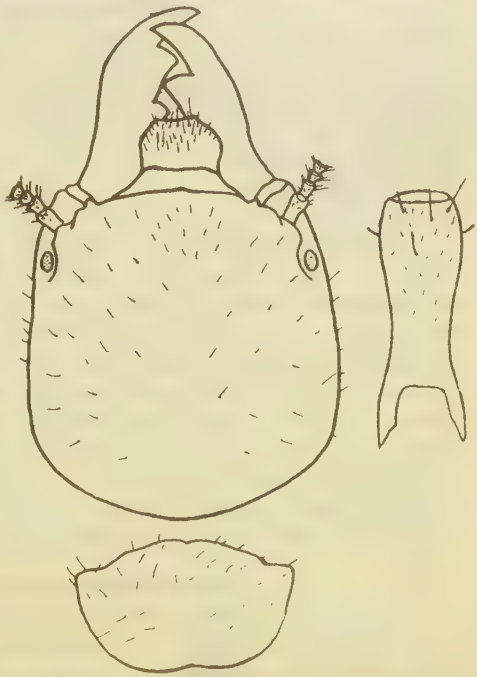


Fig. 7. *Anacanthotermes macrocephalus* (Desneux), major soldier: Dorsal view of head and pronotum; and ventral view of postmentum.

terior margin raised, indistinctly emarginate, antero-lateral corners narrowly curved.

TABLE 7

Measurements (in mm.) of the major soldier of *Anacanthotermes macrocephalus* (Desneux)

	No.	Range	Mean
Length of head with mandibles	3	6.85-7.22	6.97
Length of head to side base of mandibles	8	3.80-4.56	4.45
Width of head	8	3.70-4.56	4.19
Length of pronotum	8	1.61-1.80	1.73
Width of pronotum	8	2.86-3.25	3.03

MINOR SOLDIER : Like the major soldier in shape and colour, but smaller in size.

TABLE 8

Measurements (in mm.) of the minor soldier of *Anacanthotermes macrocephalus* (Desneux)

	No.	Range	Mean
Length of head with mandibles	5	4.60-4.97	4.79
Length of head to side base of mandibles	5	3.01-3.34	3.20
Width of head	5	2.94-3.14	2.99
Length of pronotum	5	0.98-1.33	1.15
Width of pronotum	5	1.82-2.19	2.07

DISTRIBUTION : Hyderabad, soldiers, workers, coll. T. B. Fletcher, 21.1.1921. Sargodha, soldiers, workers. coll. T. Ahmad, 14.6.1928. Sakrand, dealates, coll. Haroon Khan, 17.7.1948. Karachi, soldiers, workers, damaging jute bags, coll. Rashid Khan, 1.9.1948. Nasurpur (District Hyderabad), Soldiers and workers, ex wheat godown, coll. S. Ishfaq Hussain, 25.8.1954. Mianwali, soldiers, workers, damaging harvested maize, 7.10.1954. Quetta, soldiers, workers, ex earthen covering over willow tree, coll. M. A. Malik, 5.8.1955. Sariab (7 miles from Quetta), soldiers, workers, ex low vegetation, coll. M. A. Malik, 11.8.1955. Chaman (District Quetta-Pishin), soldiers, workers, ex earthen covering over a mulberry tree, coll. M. A. Malik, 20.9.1955.

Family **RHINOTERMITIDAE**

KEY TO THE GENERA

IMAGOES

Head round; ocelli well-developed ... ...*Coptotermes* Wasmann

Head parallel sided; ocelli poorly developed, dot-like ... ...*Heterotermes* Froggatt

SOLDIERS

Head narrowed anteriorly, frons produced into a frontal tube ... ...*Coptotermes*

Head parallel sided ... ...*Heterotermes*

Genus *Coptotermes* Wasmann

5. *Coptotermes heimi* (Wasmann)

Arrhinotermes Heimi Wasmann, 1902, p. 104 (imago). Holmgren, 1911, p. 551 (imago). Holmgren, 1913 b, p. 74 (imago, soldier, worker). Holmgren, K. & N., 1917, p. 144 (location).

Coptotermes travians Bugnion, 1910, p. 134 (biology).

Coptotermes heimi Snyder, 1949, p. 79 (synonymy).

IMAGO (Fig. 8) : Head, pronotum and tergites brown ; postclypeus brownish yellow ; anteclypeus yellowish ; eye black. Head with a few long bristles and short hairs ; postclypeus with a few bristles ; labrum with a few bristles and short hairs in the anterior half ; pronotum more hairy than the head. Head round. Eye small, not quite round, separated from the lower margin of the head by nearly one-third of its long diameter. Ocellus large, broadly oval, less than its short diameter from the eye. Fontanelle round. Antenna with 20 to 21 articles, the second one-and-a-half times as long as the third, latter slightly shorter than the fourth. Postclypeus short, nearly three times as wide as long. Labrum with anterior side straight, lateral sides broadly curved. The left mandible with three well-developed marginal teeth. The right mandible with two marginal teeth and a subsidiary tooth. Pronotum flat, slightly emarginate anteriorly and posteriorly, antero-lateral corners broadly curved. Anterior wing scales overlapping the posterior wing scales.

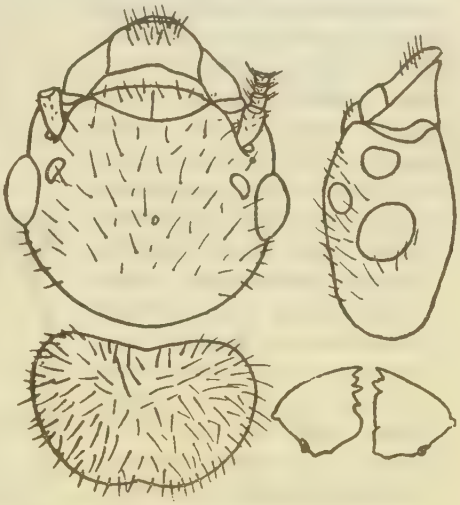


Fig. 8. *Coptotermes heimi* (Wasmann), imago : Dorsal view of head and pronotum ; side view of head ; and mandibles.

TABLE 9

Measurements (in mm.) of the imago of *Coptotermes heimi* (Wasmann)

	No.	Range	Mean
Length of head to tip of labrum	20	1.32-1.56	1.46
Length of head to side base of mandibles	21	1.06-1.20	1.16
Width of head	22	1.32-1.40	1.36
Long diameter of eye	20	0.32-0.40	0.34
Short diameter of eye	20	0.30-0.36	0.32
Eye from lower margin of head	22	0.08-0.13	0.11
Length of ocellus	22	0.11-0.17	0.14
Width of ocellus	22	0.08-0.12	0.10
Length of pronotum	22	0.68-0.76	0.71
Width of pronotum	22	1.20-1.32	1.24

SOLDIER (Fig. 9) : Head yellow, slightly darker anteriorly ; mandible reddish brown; body pale. Head with a few scattered bristles ; pronotum with two bristles at the tip ; pronotum with a few long bristles around the periphery, short hairs on other parts ; abdominal tergites densely hairy. Head oval, considerably narrowed anteriorly, frontal tube short, opening circular. Postmentum widest in the anterior third, anterior margin straight, posterior margin convex. Antenna with 14 articles, the second slightly longer than the third, the fourth and third subequal. Labrum produced into a hyaline tip. Mandibles elongate, without marginal teeth, tips curved. Pronotum flat, much narrower than the head, twice as wide as long, slighty emarginate anteriorly and posteriorly.

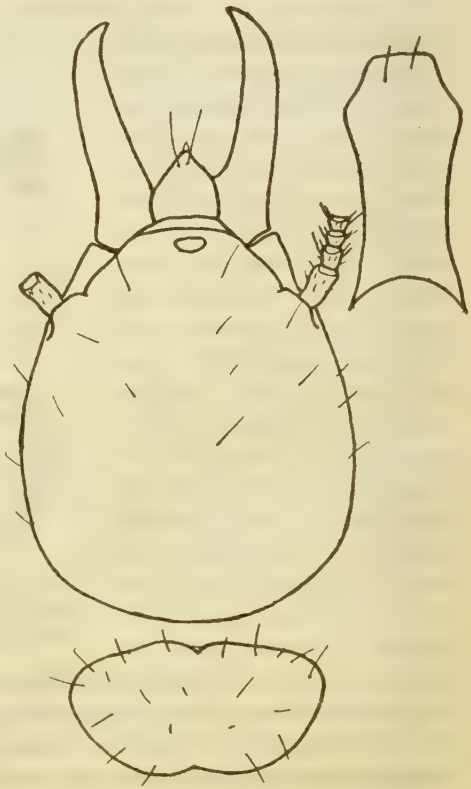


Fig. 9. *Coptotermes heimi* (Wasmann), soldier : Dorsal view of head and pronotum ; and ventral view of postmentum.

TABLE 10

Measurements (in mm.) of the soldier of *Coptotermes heimi* (Wasmann)

	No.	Range	Mean
Length of head with mandibles	69	1.82-2.12	1.96
Length of head to side base of mandibles	72	1.12-1.37	1.23
Width of head	73	0.97-1.17	1.06
Length of postmentum	41	0.73-0.87	0.80
Width of postmentum	73	0.35-0.42	0.37
Length of pronotum	73	0.37-0.47	0.40
Width of pronotum	73	0.72-0.89	0.80

DISTRIBUTION : Peshawar, soldiers and workers, ex willow tree, coll. T. B. Fletcher, 23.4.1916. Lahore, imagoes, soldiers, workers ex swarm, coll. M. Ahmad, 12.8.1951. Kotri (District Dadu), soldiers, workers, ex *Acacia arabica*, coll. S. I. Hussain, 8. 7. 1954. Sheikhupura, imagoes, soldiers, workers, coll. N. A. Bashir, 12.7.1954. Dadu, soldiers, workers, ex living *Acacia arabica*, coll. S. I. Hussain 16.7.1954. Sialkot, imagoes, soldiers, workers, coll. N. A. Bashir, 3.7.1954. Larkana, soldiers, workers, ex *Albizzia lebbek*, coll. S. I. Hussain, 4.8.1954. Jhelum, soldiers, workers, ex dry pine log, coll. N. A. Bashir, 4 9.1954. Jhat Pat (District Sibi) soldiers, workers, coll. M. A. Malik, 14.9.1955. Mehrabpur (District Sibi), soldiers, workers, ex living mango tree, coll. M. A. Malik, 15.9.1955.

Genus ***Heterotermes*** Froggatt

6. ***Heterotermes indicola*** (Wasmann)

Leucotermes indicola Wasmann 1902, p.118 (soldier, worker).
Termes (Leucotermes) indicola Desneux, 1904, p. 33 (synonymy).
Leucotermes (Leucotermes) indicola Holmgren, 1913 b, p. 64 (imago, soldier).
Leucotermes indicola Holmgren, K. & N., 1917, p. 70 (location).
Heterotermes indicola Snyder, 1949, p. 68 (synonymy).

IMAGO (Fig. 10) : Head, antennae and pronotum yellow ; meso- and metanota, and abdominal tergites paler. Head with a few long bristles and numerous short hairs ; tip of labrum with several long bristles ; pronotum slightly more hairy than the head. Head elongate, parallel sided. Eye small, not round, slightly produced antero-laterally, anterior

side straight, about its long diameter from the lower margin of the head. Ocellus indistinct, dot-like. Antenna with 16 to 19 articles, the second twice as long as the third, the fourth longer than the third. Labrum dome-shaped, about as wide as long, anterior margin straight. Mandibles as in *Coptotermes*. Pronotum slightly narrower than the head, nearly one-and-a half times as wide as long, indistinctly emarginate posteriorly.

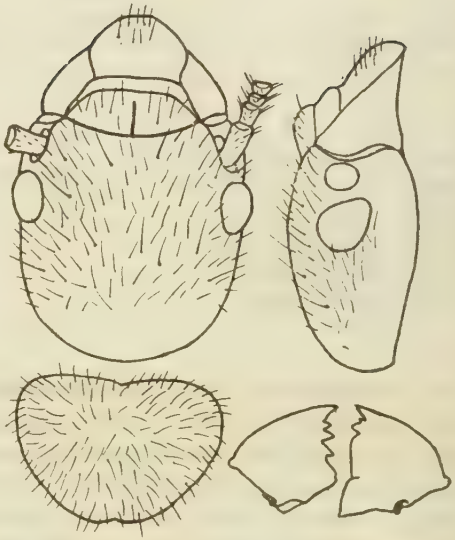


Fig. 10. *Heterotermes indicola* (Wasmann), imago: Dorsal view of head and pronotum; side view of head; and mandibles.

TABLE 11

Measurements (in mm.) of the imago of *Heterotermes indicola* (Wasmann)

	No.	Range	Mean
Length of head to tip of labrum	27	1.05-1.27	1.10
Length of head to side base of mandibles	30	0.75-0.90	0.83
Width of head	31	0.80-0.87	0.83
Long diameter of eye	32	0.20-0.24	0.22
Eye from lower margin of head	30	0.16-0.20	0.18
Length of pronotum	30	0.46-0.55	0.51
Width of pronotum	30	0.70-0.75	0.71

SOLDIER (Fig. 11): Head yellow; body paler. Head with a few bristles; tip of labrum with two long bristles and 3 to 4 short hairs; pronotum with short hairs along the anterior margin and a few scattered long bristles and short hairs in the middle. Head elongate, parallel sided, slightly less than twice as long as wide, frons gradually sloping. Postmentum twice as broad anteriorly as in the middle. Antenna

with 14 to 15 articles, the second nearly one-and-a-half times as long as the third, the fourth and third nearly subequal. Labrum with an elongate hyaline tip, one-and-a-half times as long as wide. Mandibles elongate, almost straight except the curved tips, without marginal teeth. Pronotum flat, nearly twice as broad as long, slightly emarginate anteriorly, posterior side slightly depressed in the middle.

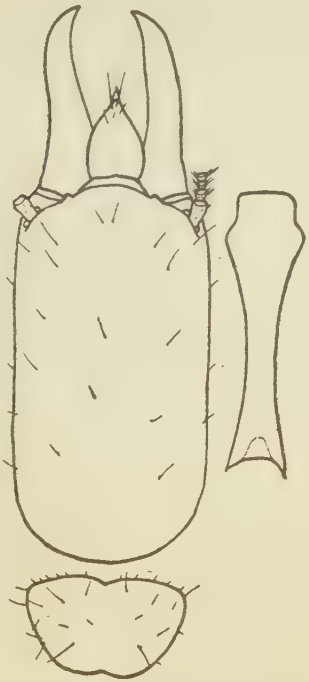


Fig. 11. *Heterotermes indicola* (Wasmann), soldier: Dorsal view of head and pronotum; and ventral view of postmentum.

TABLE 12

Measurements (in mm.) of the soldier of *Heterotermes indicola* (Wasmann)

	No.	Range	Mean
Length of head with mandibles	12	2.39-2.76	2.52
Length of head to side base of mandibles	15	1.54-1.84	1.72
Width of head	20	0.91-0.96	0.93
Length of postmentum	13	1.20-1.34	1.26
Width of postmentum	14	0.39-0.42	0.40
Length of pronotum	13	0.44-0.52	0.46
Width of pronotum	12	0.78-0.83	0.80

DISTRIBUTION: Hangu (District Kohat), soldiers, workers, ex rotten stem of mulberry tree, coll. T.B. Fletcher, 18.5.1915. Abbottabad (4000 ft.), soldiers, workers, ex dead tree, coll. T.B. Fletcher, 9.6.1916. Tret (Murree,

District Rawalpindi), soldiers, workers, ex *Pinus longifolia*, coll. M. A. H. Qadri, 14.4.1950. Lahore, imagoes, soldiers, workers ex wooden cycle stand, coll. M. Ahmad, 18.8.1951. Shinkiari (near Abbottabad), imagoes, soldiers, workers, ex stump of *Pinus longifolia*, coll. Ghulamullah, 11.7.1953. Lyallpur, imagoes, soldiers, workers, ex wooden structure of a building, coll. N. A. Bashir, 10.7.1954. Gujrat, imagoes, soldiers, workers, ex *Dalbergia sissoo*, coll. N.A. Bashir, 1.9.1954. Murree (District Rawalpindi), soldiers, workers, ex *Pinus longifolia*, coll. N. A. Bashir, 20.10.1954. Sakesar (4892 ft.) in District Sargodha, soldiers, workers, ex pine tree, coll. M. Ahmad and M. Saleem, April, 1955. Quetta, soldiers, workers, ex living mulberry tree, coll. M. A. Malik, 3.8.1955. Pishin (District Quetta-Pishin), ex living mulberry tree, coll. M. A. Malik, 26.8.1955. Fort Sandeman (District Zhob), soldiers, workers, ex woodwork of an old house, coll. M. A. Malik, 20.8.1955. Chaman (District Quetta-Pishin), ex living mulberry tree, coll. M. A. Malik, 20.9.1955.

Family TERMITIDAE

KEY TO THE GENERA

IMAGOES

1. Posterior cutting edge of second marginal of right mandible straight 2

   Posterior cutting edge of second marginal of right mandible concave 5

2. Labrum longer than broad, with a chitinous transverse band in the middle ; left mandible with a deep cut between marginal teeth, posterior cutting edge of first marginal long, curved posteriorly 3

   Labrum as long as or shorter than broad, without the chitinous transverse band ; left mandible without deep cut between marginal teeth 4

3. Antenna with 15 to 18 articles ; postclypeus strongly arched, much lighter than head ; wings unusually long, with a network of veinlets between median and radius sector ... ... *Microtermes* Wasmann

   Antenna with 19 to 23 articles ; postclypeus not much lighter than head ; wings not unusually long ... *Odontotermes* Holmgren

4. Left mandible with only first marginal, with posterior cutting edge broadly curved ; head round ... ... *Amitermes* Silvestri

   Left mandible with two marginal teeth ; head parallel sided ... ... *Microcerotermes* Silvestri

5. Left mandible with widely separated marginal teeth ; second marginal small, round ... ... *Eremotermes* Silvestri

Left mandible with marginal teeth approximated ; second marginal tooth pointed ....*Capritermes* Wasmann

SOLDIERS

1. Head with frontal projection 2

Head without frontal projection 3

2. Mandibles with a sharply pointed tooth, almost straight, only slightly curved at tip ; labrum narrowly pointed ... ... *Eremotermes*

Mandibles without tooth, tip hooked ; labrum concave ... ... *Angulitermes* Sjostedt

3. Postmentum broad, strongly arched 4

Postmentum narrow, not arched, flat 5

4. Mandibles stout ; large species ; antenna with 15 to 19 articles ... ...

Left mandible with a prominent, sharply pointed, anteriorly directed tooth in anterior third... 2

2. Head only slightly narrowed anteriorly, side moderately convex ... ... *Odontotermes* (*O.*) *gurdaspurensis* Holmgren, K. & N.

Head considerably narrowed anteriorly 3

3. Labrum narrowly curved at tip ... ... *Odontotermes (O.) bangalorensis* Holmgren

Labrum broadly curved at tip ... ... *Odontotermes (O.) obesus*

7. *Odontotermes (O.) obesus* (Rambur)

Termes obesus Rambur, 1842, p. 304 (imago).

Odontotermes (Cyclotermes) obesus Holmgren, 1912, p. 38 (soldier). Holmgren, 1913 b, p. 108 (imago, soldier, worker). Holmgren, K. & N., 1917, p. 145 (location).

Odontotermes (Odontotermes) obesus Snyder, 1949 p. 235 (synonymy).

IMAGO (Fig. 12) : Head reddish brown, slightly darker between the eyes ; labrum pale, with a brownish transverse band in the middle ; pronotum of the same colour as the head, with a yellow T-shaped median marking and an ocellus-like marking on each antero-lateral corner. Head with numerous long bristles and short hairs ; clypeus with long bristles and short hairs except in the middle ; pronotum more hairy than the head. Head round. Eye large, bulging, almost round, separated from the lower margin of the head by nearly one-fifth of its long diameter. Ocellus large, oval, separated from the eye by about one-third of its long diameter. Antenna with 19 articles, the second nearly twice as long as the fourth, the third shortest. Postclypeus strongly arched, half as long

Fig. 12. *Odontotermes (O.) obesus* (Rambur), imago : Dorsal view of head and pronotum ; side view of head ; and mandibles.

as wide. Anteclypeus membranous, more than twice as wide as long. Labrum longer than wide. The left mandible with two widely separated marginal teeth, the posterior cutting edge of the first marginal long, sigmoid. The right mandible with two approximated marginal teeth, the posterior cutting edge of the first marginal tooth concave. Pronotum slightly narrower than the head, nearly twice as wide as long, anterior margin straight, slightly notched in the middle, the posterior margin slightly depressed in the middle.

TABLE 13

Measurements (in mm.) of the imago of *Odontotermes (O.) obesus* (Rambur)

	No.	Range	Mean
Length of head to tip of labrum	10	2.70-2.92	2.85
Length of head to side base of mandibles	10	1.92-2.12	1.97
Width of head	10	2.76-2.88	2.82
Long diameter of eye	10	0.74-0.81	0.77
Eye from lower margin of head	10	0.14-0.18	0.16
Length of ocellus	10	0.37-0.40	0.38
Ocellus from eye	10	0.10-0.14	0.13
Length of pronotum	10	1.24-1.36	1.28
Width of pronotum	10	2.36-2.51	2.43

SOLDIER (Fig. 13) : Head light reddish brown ; mandibles dark reddish brown excepting at the base ; antennae brownish yellow in the proximal half, brown in the distal half ; pronotum slightly lighter than the head ; legs and abdomen brownish yellow. Head with a few scattered long bristles ; labrum with a row of bristles along the periphery ; postmentum with three to four bristles at the tip ; pronotum sparsely hairy, with a few long bristles along the lateral and postero-lateral margins. Head oval, narrowed anteriorly. Postmentum arched, one-and-a-half times as long as wide, widest a little anterior to the middle. Antenna with 16 to 17 articles, the second nearly as long as the third and fourth combined. Labrum tongue-shaped, broadly rounded anteriorly, sides slightly

Fig. 13. *Odontotermes (O.) obesus* (Rambur), soldier : Dorsal view of head and pronotum ; and ventral view of postmentum.

convex. Mandibles slender, curved ; left mandible with a sharply pointed and anteriorly directed tooth in the anterior third ; right mandible with a rudimentary tooth a little anterior to the middle. Pronotum saddle-shaped, slightly more than one-and-a-half times as wide as long, slightly emarginate anteriorly and posteriorly.

TABLE 14

Measurements (in mm.) of the soldier of *Odontotermes* (*O.*) *obesus* (Rambur)

	No.	Range	Mean
Length of head with mandibles	33	1.97-2.45	2.26
Length of head to side base of mandibles	40	1.25-1.52	1.40
Width of head	38	1.05-1.25	1.17
Length of postmentum	33	0.62-0.87	0.77
Width of postmentum	35	0.45-0.52	0.47
Length of pronotum	40	0.50-0.57	0.53
Width of pronotum	35	0.77-1.02	0.85

DISTRIBUTION : Tarnab (District Peshawar), soldiers, workers, ex living maize, coll. T. B. Fletcher, 22.4.1916. Lahore, soldiers, workers, ex mound, coll. M.A. Khan and M. Ahmad, 12.8.1952. Hyderabad, 2 imagoes, soldiers, workers, ex earthen covering over *Acacia arabica*, coll. S.I. Hussain. Lyallpur, imagoes, soldiers, workers, ex mound, coll. N.A. Bashir, 30.7.1954. Sialkot, soldiers, workers, ex mound, coll. N.A. Bashir, 5.8.1954.

8. *Odontotermes* (*O.*) *gurdaspurensis* Holmgren, K. & N.

Odontotermes (Cyclotermes) obesus f. *gurdaspurensis* Holmgren, K. & N., 1917, p. 149, (imago, soldier, worker).

Odontotermes (Odontotermes) obesus f. *gurdaspurensis* Snyder, 1949, p. 235, (synonymy).

SOLDIER (Fig. 14) . Head reddish brown ; mandibles dark reddish brown ; proximal articles of antenna light brown, distal articles dark brown ; labrum light reddish brown ; rest of the body brownish yellow. Head with a few scattered long bristles ; labrum with bristles along the periphery ; postmentum with a few bristles in the anterior half ; pronotum with small hairs along the antero-lateral margins ; a few long bristles at the edge of lateral lobes. Head broadly oval, slightly narrowed anteriorly. Postmentum arched, more than twice as wide as long. Antenna with 16 articles, the second nearly twice as long as

the third and fourth combined. Labrum longer than wide, rather narrowly curved anteriorly. Mandibles long, slender, curved; left mandible with a sharply pointed and anteriorly directed tooth at the base of the apical third; right mandible with an indistinct denticle in the median third. Pronotum saddle-shaped, nearly twice as wide as long, anterior margin indistinctly notched in the middle, posterior margin distinctly emarginate.

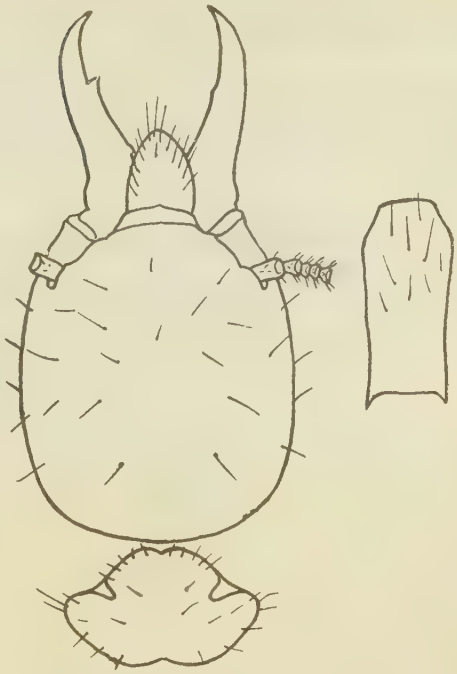


Fig. 14. *Odontotermes* (*O.*) *gurdaspurensis* Holmgren, K. & N., soldier : Dorsal view of head and pronotum ; and ventral view of postmentum.

TABLE 15

Measurements (in mm.) of the soldier of *Odontotermes* (*O.*) *gurdaspurensis* Holmgren, K. & N.

	No.	Range	Mean
Length of head with mandibles	12	2.23-2.40	2.37
Length of head to side base of mandibles	12	1.41-1.55	1.50
Width of head	12	1.13-1.29	1.23
Length of postmentum	12	0.80-0.92	0.86
Width of postmentum	12	0.40-0.46	0.42
Length of pronotum	12	0.46-0.58	0.53
Width of pronotum	12	0.83-0.99	0.92

REMARKS : *Odontotermes* (*O.*) *gurdaspurensis* was described as a form of *Odontotermes* (*O.*) *obesus* by Holmgren, K. &. N. I consider it to be a distinct species and have so designated it. It can be easily distinguished

from *obesus* by its less anteriorly narrowed head and more posteriorly located tooth of the left mandible.

DISTRIBUTION : Lahore, 4 soldiers and workers, ex *Acacia arabica* coll. M. A. Khan, 15.7.1952. Bharakow (District Muzaffarabad, Azad Kashmir), soldiers, workers, ex *Dalbergia* tree, coll. M.A. Khan, 26.8.1955.

9. *Odontotermes (O.) bangalorensis* Holmgren

Odontotermes (Odontotermes) bangalorensis Holmgren, 1913a, p. 105-109 (imago, queen, soldier, worker) ; Holmgren 1913b, p. 112 (imago, queen soldier, worker). Snyder, 1949, p. 221 (synonymy).

Odontotermes (Cyclotermes) bangalorensis Holmgren, K. & N., 1917, p. 151 (location).

SOLDIER (Fig. 15) : Head reddish brown ; mandibles dark reddish brown ; proximal articles of antenna light brown, distal articles dark brown ; pronotum slightly lighter than the head. Head with a few scattered bristles and short hairs ; postmentum with a few bristles in the anterior half ; labrum with bristles along the periphery ; pronotum with a few scattered short hairs on the surface, the margins with a few long bristles. Head oval, distinctly narrowed anteriorly, widest in the posterior half. Postmentum arched, widest in the anterior half, nearly one-and-a-half times as long as the third and fourth combined. Labrum longer than broad, narrowly rounded anteriorly. Mandibles sabre-shaped ; left mandible with a sharply pointed, and forwardly directed tooth at the base of the apical third ; right mandible without any denticle. Pronotum saddle-shaped, nearly twice as wide as long, slightly emarginate anteriorly and posteriorly.

Fig. 15. *Odontotermes (O.) bangalorensis* Holmgren, soldier : Dorsal view of head and pronotum ; and ventral view of postmentum.

TABLE 16

Measurements (in mm.) of the soldier of *Odontotermes* (*O.*) *bangalorensis* Holmgren

	No.	Range	Mean
Length of head with mandibles	6	1.79-1.99	1.89
Length of head to side base of mandibles	8	1.08-1.21	1.15
Width of head	8	0.93-1.14	1.07
Length of postmentum	8	0.60-0.66	0.64
Width of postmentum	8	0.44-0.47	0.42
Length of pronotum	8	0.40-0.50	0.48
Width of pronotum	8	0.68-0.88	0.86

DISTRIBUTION : Lahore, soldiers, workers, from mound, coll. M. A. Khan, 8.7.1952. Lyallpur, soldiers, workers, ex earthen tubes over a log of wood, coll. N. A. Bashir, 16.10.1954.

10. *Odontotermes (O.) almorensis* (Snyder)

Termes (Cyclotermes) almorensis Snyder, 1933 b, p. 8 (imago). *Odontotermes (Odontotermes) almorensis* Snyder, 1949, p. 219 (synonymy).

IMAGO (Fig. 16) : Head dark brown ; mandibles dark reddish brown, teeth almost black ; the transverse chitinous band of labrum, postclypeus and antennae brown ; pronotum of the same colour as head, the T-shaped median marking and the ocellus-like marking on antero-lateral corners yellow; abdominal tergites dark brown. Head thickly hairy, with long bristles and short hairs ; postclypeus with long bristles and short hairs ;

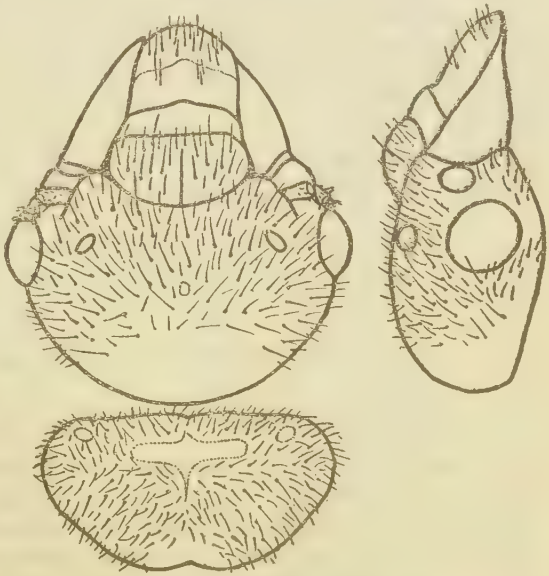


Fig. 16. *Odontotermes (O.) almorensis* (Snyder), imago : Dorsal view of head and pronotum ; and side view of head.

labrum with bristles and short hairs in the anterior half. Head round, wider than long (without mandibles). Eye of medium size, almost round, separated from the lower margin of the head by slightly more than one-third of its long diameter. Ocellus rather small, broadly oval, slightly longer than wide, separated from the eye by more than its long diameter. Postclypeus almost half as long as wide. Antenna with 19 articles, the second nearly as long as the third and fourth combined. Pronotum slightly narrower than the head, twice as wide as long, anterior margin almost straight, with a small notch in the middle, posterior margin shallowly emarginate.

TABLE 17

Measurements (in mm.) of the imago of *Odontotermes* (*O.*) *almorensis* (Snyder)

	No.	Range	Mean
Length of head to tip of labrum	9	2.88-3.06	2.93
Length of head to side base of mandibles	9	1.85-1.96	1.90
Width of head	10	2.55-2.77	2.63
Large diameter of eye	10	0.55-0.64	0.59
Short diameter of eye	10	0.48-0.55	0.51
Eye from lower margin of head	10	0.18-0.22	0.19
Length of ocellus	10	0.22-0.26	0.23
Width of ocellus	10	0.18-0.22	0.19
Ocellus from eye	10	0.30-0.34	0.31
Length of pronotum	10	1.14-1.22	1.18
Width of pronotum	10	2.25-2.43	2.33

DISTRIBUTION: Upper Topa (Muree, District Rawalpindi), imagoes, ex swarm, coll. M. A. H. Qadri, 7.6.1952 Abbottabad, ex swarm, coll. Ghulamullah, 21.5.1953.

11. *Odontotermes (O.) dehraduni* (Snyder)

Termes (Termes) dehraduni Snyder, 1933b, pp. 6-7 (imago).
Odontotermes (Odontotermes) dehraduni Snyder, 1949, p. 224 (synonymy).

IMAGO (Fig. 17) : Head dark reddish brown, slightly darker between the eyes ; antennae brown ; pronotum of the same colour as the head, the T-shaped median marking and the ocellus-like marking on each antero-lateral corner yellow ; abdominal tergites brown. Head densely hairy, with forwardly directed long bristles and short hairs ; pronotum more pubescent than the head. Head round. Fontanelle small, round, situated a little below the level of the ocelli. Eye large, bulging, almost round, separated from the lower margin of the head by one-

fifth of its long diameter. Ocellus large, bulging, broadly oval, less than half of its short diameter from the eye. Antenna with 19 articles, the second one-and-a-half times as long as the third, the fourth slightly shorter than the third. Post-clypeus not strongly swollen, less than half as long as wide. Labrum large, dome-shaped. Pronotum only slightly narrower than the head, nearly twice as wide as long, anterior margin almost straight, indistinctly notched in the middle, posterior margin slightly depressed in the middle.

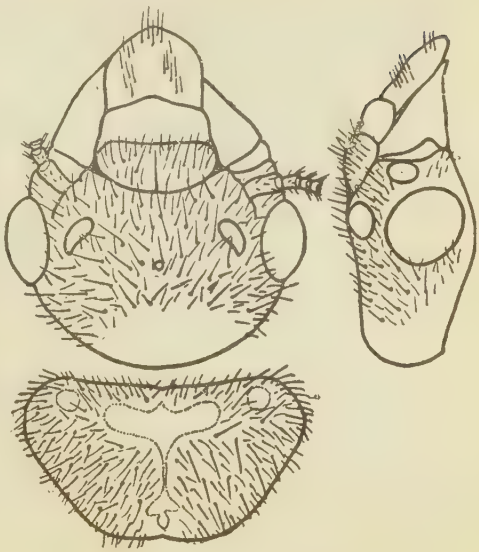


Fig. 17. *Odontotermes (O.) dehraduni* (Snyder), imago : Dorsal view of head and pronotum ; side view of head.

TABLE 18

Measurements (in mm.) of the imago of *Odontotermes* (*O.*) *dehraduni* (Snyder)

	No.	Range	Mean
Length of head to tip of labrum	11	2.35-2.75	2.50
Length of head to side base of mandibles	12	1.57-1.80	1.70
Width of head	12	2.27-2.45	2.30
Long diameter of eye	12	0.67-0.72	0.70
Eye from lower margin of head	13	0.10-0.12	0.11
Length of ocellus	13	0.30-0.37	0.35
Width of ocellus	13	0.22-0.27	0.25
Ocellus from eye	12	0.10-0.12	0.10
Length of pronotum	13	1.10-1.20	1.16
Width of pronotum	13	2.07-2.30	2.18

DISTRIBUTION : Lahore, imagoes, at light, coll. M. A. Khan, 17.7.1952. Jhelum, imagoes, ex swarm, coll. N. A. Bashir, 3.9.1954. Rawalpindi, ex swarm, coll. N. A. Bashir, 9.9.1954.

12. *Odontotermes (O.) parvidens* Holmgren, K. & N.

Odontotermes (Odontotermes) parvidens Holmgren, K. & N., 1917, p. 154 (soldier). Snyder, 1949, p. 236.

SOLDIER (Fig. 18) : Head light reddish brown ; mandibles reddish

brown at the base; dark brown in the outer three-fourths; antennae and pronotum brownish yellow. Head sparsely hairy; labrum with a few bristles at the tip and at antero-lateral margins; postmentum with 2 to 3 bristles anteriorly; pronotum more hairy than the head. Head slightly narrowed anteriorly, widest a little behind the middle. Postmentum more than twice as long as wide. Antenna with 16 articles, the second one-and-a-half times as long as the third. Labrum with narrowly pointed tip, extending up to the basal fourth of the mandibles. Mandibles stout, slightly curved apically; left mandible with a small tooth in the basal third, right mandible without any denticle. Pronotum saddle-shaped, anterior margin not emarginate, posterior margin shallowly emarginate.

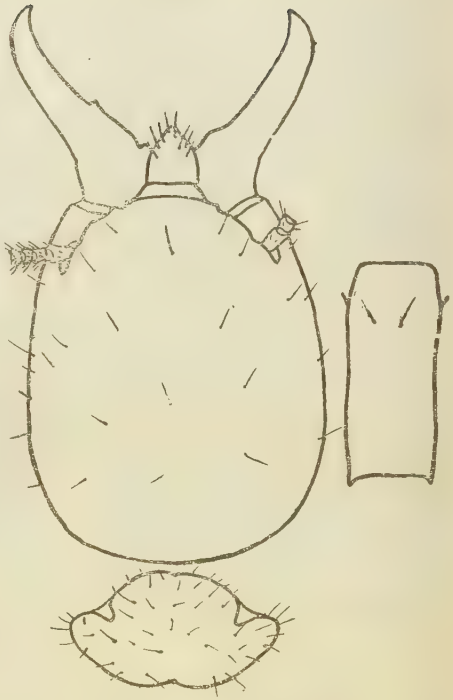


Fig. 18. *Odontotermes* (*O.*) *parvidens* Holmgren, K. & N., soldier: Dorsal view of head and pronotum; and ventral view of postmentum.

TABLE 19

Measurements (in mm.) of the soldier of *Odontotermes (O.) parvidens* Holmgren, K. & N.

	No.	Range	Mean
Length of head with mandibles	10	3.73-3.83	3.76
Length of head to side base of mandibles	10	2.22-2.51	2.32
Width of head	10	1.88-2.07	1.98
Length of postmentum	10	1.40-1.48	1.45
Width of postmentum	10	0.66-0.70	0.68
Length of pronotum	10	0.69-0.74	0.70
Width of pronotum	10	1.36-1.48	1.42

DISTRIBUTION: Balakot (District Hazara), soldiers, workers, coll. M. Ahmad, 22.8.1950. Abbottabad, soldiers, workers, ex dead tree, coll. Ghulamullah. Hangora (Swat), soldiers, workers, coll. M. Saleem,

Genus *Microtermes* Wasmann

KEY TO THE SPECIES

IMAGOES

1. Ocellus very close to eye, separated by about one-third of its short diameter ... ... *M. unicolor* Snyder

   Ocellus farther away from eye 2

2. Postclypeus distinctly shorter than half of its width, large species, head width 1.77-1.82 mm. ... ... *M. mycophagus* (Desneux)

   Postclypeus half as long as wide ; small species, head width 1,33-1.49 mm. 3

3. Eye separated from lower margin of head by about half of its short diameter ; colour dark brown... ... ... *M. sindensis* (Desneux)

   Eye closer to lower margin of head, separated by about one-fourth of its short diameter ; colour reddish brown ... ...*M. obesi* Holmgren

SOLDIERS

1. Labrum with broadly curved tip. ... ... *M. mycophagus*
   Labrum lancet shaped 2

2. Moderately hairy ... ... *M. obesi*
   Densely hairy ... ... *M. unicolor*

13. *Microtermes unicolor* Snyder

Microtermes unicolor Snyder, 1933a, pp. 92-93, (king, queen). Snyder, 1949, p. 254 (synonymy).

Microtermes pubescens Snyder, 1933b, pp. 9-10 (soldier).

IMAGO (Fig. 19) : Head brown, lighter around the fontanelle ; mandibles light reddish brown; labrum and antennae light brown ; pronotum yellowish brown, antero-lateral sides darker ; meso-and metanota slightly lighter than the pronotum, posterior parts darker than anterior parts ; abdominal tergites brownish ; wing veins brown. Head moderately hairy ; labrum with numerous fine hairs in the anterior half ; pronotum moderately pubescent. Head round. Eye large, bulging, almost round, separated from the lower margin of the head by about one third of its short diameter. Ocellus large, broadly oval, very close to the eye, separated by about one-third of its short diameter. Antenna with 15 articles, the second slightly longer than the third. Postclypeus strongly arched, more than half as

long as wide. Anteclypeus membranous, trapezoid, more than twice as wide as long, labrum large, dome-shaped. Mandibles as in *Odontotermes*. Pronotum almost as wide as the head, indistinctly emarginate anteriorly, posterior margin distinctly emarginate, with a T-shaped median marking and an ocellus-like marking on each antero-lateral corner.

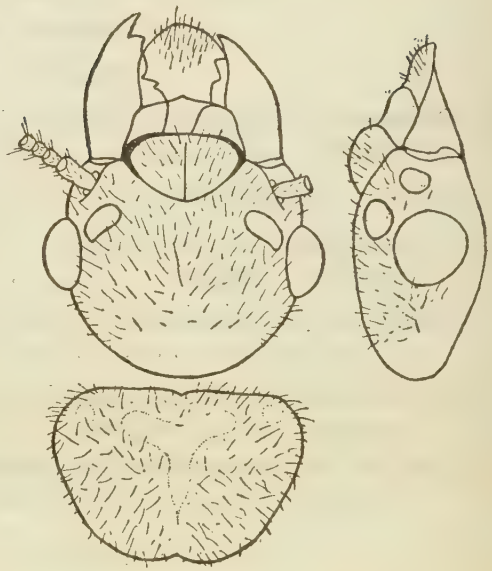


Fig. 19. *Microtermes unicolor* Snyder, imago : Dorsal view of head and pronotum ; and side view of head.

TABLE 20

Measurements (in mm.) of the imago of *Microtermes unicolor* Snyder

	No.	Range	Mean
Length of head to side base of mandibles	10	1.03-1.11	1.07
Width of head	10	1.36-1.44	1.39
Length of eye	10	0.40	0.40
Width of eye	10	0.35-0.37	0.36
Eye from lower margin of head	10	0.09-0.11	0.10
Length of ocellus	10	0.18-0.25	0.20
Width of ocellus	10	0.12-0.18	0.14
Ocellus from eye	10	0.03-0.07	0.05
Length of pronotum	10	0.74-0.81	0.77
Width of pronotum	10	1.22-1.25	1.23

SOLDIER (Fig. 20) : Head yellowish ; mandibles reddish brown at the base, dark reddish brown in the outer three-fourths ; pronotum pale. Head densely hairy ; labrum with a few long bristles and short hairs in the anterior half; pronotum less pubescent than the head. Head oval, narrowed

anteriorly. Postmentum arched, slightly longer than wide. Antenna with 14 articles; the second slightly less than the third and fourth combined, the third and fourth subequal. Labrum lancet-shaped, considerably narrowed anteriorly, widest in the basal half. Mandibles slender, without marginal teeth. Pronotum saddle-shaped, deeply notched anteriorly, posterior side slightly emarginate.

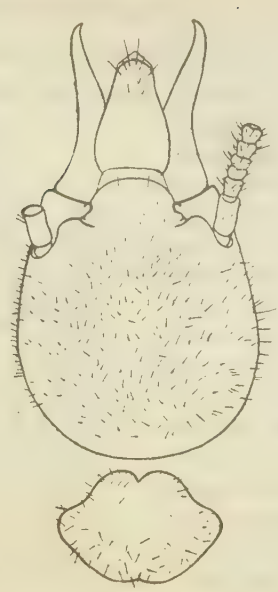


Fig. 20. *Microtermes unicolor* Snyder, soldier: Dorsal view of head and pronotum.

TABLE 21

Measurements (in mm.) of the soldier of *Microtermes unicolor* Snyder

	No.	Range	Mean
Length of head with mandibles	12	1.40-1.54	1.48
Length of head to side base of mandibles	12	0.88-0.95	0.92
Width of head	12	0.72-0.82	0.78
Length of postmentum	12	0.36-0.45	0.43
Width of postmentum	12	0.35-0.41	0.37
Length of pronotum	12	0.30-0.34	0.31
Width of pronotum	12	0.50-0.57	0.52

DISTRIBUTION : Lahore, imagoes, coll. G. Yazdani, 13.7.1950. Lahore, soldiers, workers, coll. M. A. Khan, 10.8.1952. Pirawala (District Multan), soldiers, workers, ex *Dalbergia sisso*, coll. Ghulamullah, 20.7.1953. Mardan, imagoes, ex swarm, coll. Fazle Majid Khan, 18.8.1954.

14. *Microtermes obesi* Holmgren

Microtermes obesi Holmgren, 1913b, p. 150 (imago). Holmgren, K. & N., 1917, p. 159 (location). Snyder, 1949, p. 252 (synonymy).

Microtermes Anandi Holmgren, 1913a, p. 114. Holmgren, 1913b, p. 152 (soldier,

worker). Holmgren, K. & N., 1917, p. 160 (location). Silvestri, 1923, p. 225 (location).

Microtermes Anandi f. *curvignathus* Holmgren, 1913b, p. 153 (soldier, worker).

IMAGO (Fig. 21): Head dark reddish brown; mandibles yellowish brown; postclypeus brownish yellow; pronotum lighter than the head; meso-and metanota of the same colour as the pronotum, anterior and posterior parts uniformly coloured. Head sparsely hairy, a few long bristles mixed with short hairs; labrum and postclypeus with a few long bristles and short hairs; pronotum more hairy than the head. Head round. Eye bulging, almost round, separated from the lower margin of the head by slightly less than one-third of its long diameter. Ocellus of medium size, oval, separated from the eye by about its short diameter. Fontanelle small, round. Antenna with 15 articles, the second a little longer than the third, the fourth and third subequal. Postclypeus strongly arched, half as long as wide. Mandibles as in *Odontotermes*. Pronotum slightly narrower than the head, slightly more than one-and-a-half times as wide as long, anterior margin almost straight, posterior margin shallowly depressed.

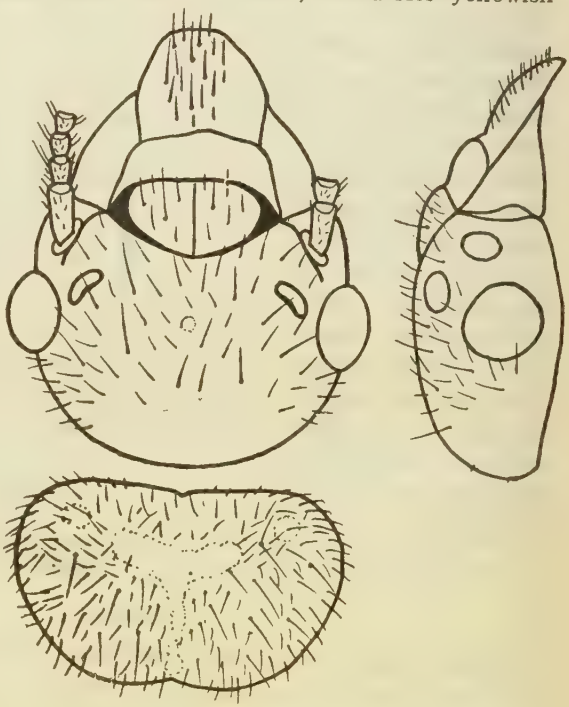


Fig. 21. *Microtermes obesi* Holmgren, imago: Dorsal view of head and pronotum; and side view of head.

TABLE 22

Measurements (in mm.) of the imago of *Microtermes obesi* Holmgren

	No.	Range	Mean
Length of head to tip of labrum	10	1.62-1.73	1.66
Length of head to side base of mandibles	10	1.08-1.15	1.12
Width of head	10	1.33-1.42	1.38
Length of eye	10	0.36-0.40	0.38

	No.	Range	Nean
Width of eye	10	0.32-0.36	0.33
Eye from lower margin of head	10	0.10-0.12	0.11
Length of ocellus	10	0.18-0.20	0.19
Width of ocellus	10	0.10-0.12	0.11
Ocellus from eye	10	0.08-0.10	0.09
Length of pronotum	10	0.68-0.83	0.74
Width of pronotum	10	1.22-1.30	1.26

SOLDIER (Fig. 22) : Head brownish yellow ; mandibles dark reddish brown in the outer three-fourths, brownish yellow in the basal fourth ; pronotum pale. Head moderately hairy, with a few long bristles and more numerous short hairs ; labrum with a few long bristles at the tip ; postmentum with a few bristles in the anterior half ; pronotum with a few long bristles at the margins, short hairs in the middle. Head oval, narrowed anteriorly. Postmentum arched, about as wide as long. Antenna with 14 articles, the second nearly as long as the third and fourth combined. Mandibles slender, curved at tip. Pronotum saddle-shaped, distinctly notched anteriorly, posterior margin indistinctly emarginate.

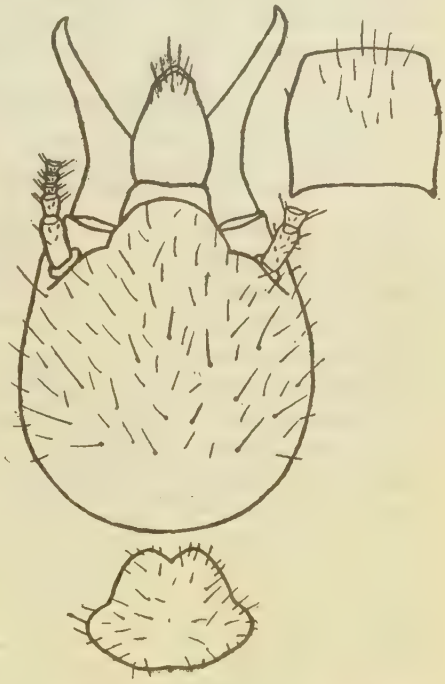


Fig. 22. *Microtermes obesi* Holmgren, soldier ; Dorsal view of head and pronotum ; and ventral view of postmentum.

TABLE 23

Measurements (in mm.) of the soldier of *Microtermes obesi* Holmgren

	No.	Range	Mean
Length of head with madibles	15	1.15-1.36	1.23
Length of head to side base of mandibles	19	0.76-0.85	0.80
Width of head	19	0.70-0.76	0.73

	No.	Range	Mean
Length of postmentum	16	0.37-0.42	0.39
Width of postmentum	17	0.35-0.38	0.36
Length of pronotum	19	0.28-0.35	0.31
Width of pronotum	19	0.46-0.53	0.49

DISTRIBUTION : Tarnab (District Peshawar), soldiers, workers, ex rotten stump, coll. T. B. Fletcher, 24. 6. 1916. Lahore; imagoes, ex swarm coll. M. Ahmad, 7. 8. 1953. Kotri (District Dadu), soldiers, workers, ex *Acacia arabica*, coll. S. I. Hussain 2. 9. 1954. Mirpur Khas, soldiers, workers, ex *Ficus religiosa*, coll. S. I. Hussain, 17. 9. 1954.

15. *Microtermes mycophagus* (Desneux)

Termes mycophagus Desneux, 1906, p. 348 (imago, soldier, worker).
Microtermes mycophagus Holmgren, 1913b, p. 150 (imago, soldier, worker). Holmgren, K. & N., 1917, p. 159 (location). Snyder, 1949, p. 252 (synonymy).

IMAGO (Fig. 23) : Head reddish brown ; mandibles brownish yellow ; postclypeus light brownish yellow; pronotum much lighter than the head ; meso- and metanota of the same colour as the pronotum; abdominal tergites brownish. Head moderately hairy, with long bristles and short hairs ; pronotum as hairy as the head. Head round. Eye large, bulging, separated from the lower margin of the head by about half of its long diameter. Ocellus large, oval, one-and-a-half times as long as wide, separated from the eye by about half of its length. Fontanelle prominent, situated at the level of the lower margin of the eyes.

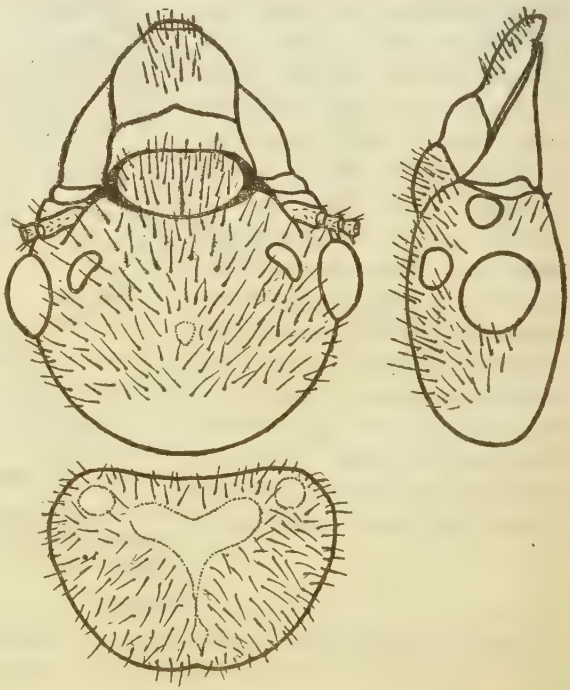


Fig. 23. *Microtermes mycophagus* (Desneux), imago: Dorsal view of head and pronotum; and side view of head.

Antenna with 17 to 18 articles, the second as long as the third and fourth combined, the fourth shortest. Pronotum narrower than the head, anterior margin slightly raised, very shallowly concave, posterior margin slightly emarginate.

TABLE 24

Measurements (in mm.) of the imago of *Microtermes mycophagus* (Desneux)

	No.	Range	Mean
Length of head to tip of labrum	17	2.17-2.37	2.22
Length of head to side base of mandibles	15	1.35-1.50	1.41
Width of head	15	1.77-1.85	1.82
Length of eye	15	0.43-0.52	0.48
Width of eye	15	0.40-0.45	0.43
Eye from lower margin of head	15	0.18-0.22	0.20
Length of ocellus	14	0.17-0.27	0.23
Width of ocellus	14	0.16-0.18	0.18
Ocellus from eye	14	0.09-0.13	0.10
Length of pronotum	15	0.90-1.05	0.93
Width of pronotum	15	1.52-1.73	1.68

SOLDIER (Fig. 24): Head light reddish brown; mandibles brownish yellow in the basal third, dark reddish brown in the outer two-thirds; rest of the body brownish yellow. Head densely hairy; labrum with long bristles at the tip and around the lateral margins; postmentum with a few bristles in the anterior half; pronotum less hairy than the head. Head broadly oval, widest in the middle. Postmentum strongly arched, almost as wide as long, widest a little posterior to the middle, anterior and posterior margins straight. Antenna with 15 articles, the second as long as the third and fourth combined, the fourth longer than the third and fifth. Labrum tongue-shaped, broadly curved anterior-

Fig. 24. *Microtermes mycophagus* (Desneux), soldier: Dorsal view of head and pronotum; and ventral view of postmentum.

ly, extending up to three-fourths of the mandibles. Pronotum saddle-shaped, distinctly notched anteriorly, lateral lobes broadly curved, posterior margin indistinctly emarginate.

TABLE 25

Measurements (in mm.) of the soldier of *Microtermes mycophagus* (Desneux)

	No.	Range	Mean
Length of head with mandibles	43	1.37-1.65	1.58
Length of head to side base of mandibles	48	0.82-1.05	0.92
Width of head	47	0.77-0.97	0.87
Length of postmentum	47	0.42-0.52	0.47
Width of postmentum	47	0.37-0.46	0.42
Length of pronotum	48	0.37-0.46	0.40
Width of pronotum	49	0.56-0.70	0.63

DISTRIBUTION : Malir City, Karachi, soldiers, workers, ex dry log, coll. Taufiq H. Khan, 10.10.1948. Sakrand, soldiers, workers, damaging cotton crop, coll, Haroon Khan, 11.6.1949. Lahore, soldiers, workers under a brick, coll. M. Ahmad, 6.9.1952. Lahore, imagoes, at light, coll. M. A. Khan, 19.7.1952. Chichawatni (District Montgomery), soldiers, workers, ex grass, coll. Ghulamullah, 24.7.1953. Hyderabad, soldiers, workers, coll. S. I. Hussain, 17.7.1954. Sialkot, soldiers, workers, ex dead portion of a tree, coll. N. A. Bashir, 20.7.1954. Larkana, one soldier, ex living *Acacia arabica*, coll. S. I. Hussain, 28.7.1954. Lyallpur, imagoes, soldiers, workers, ex earthen tubes built over *Dalbergia sisso*, coll. N. A. Bashir, 30.7.1954. Sukkur, soldiers, workers, ex living *Dalbergia sisso*, coll. S. I. Hussain, 31.7.1954. Sheikhupura, soldiers, workers, ex *Dalbergia sisso*, coll. N. A. Bashir, 15.8.1954. Jhelum, soldiers, workers, ex *Acacia arabica*, coll. N. A. Bashir, 4.9.1954. Kotri (District Dadu), imagoes, at light, coll. S. I. Hussain, 5.9.1954. Jhang, soldiers, workers, ex *Dalbergia sisso*, coll. N. A. Bashir, 10.11.1954. Usta Muhammad (District Sibi), soldiers, workers, coll. M. A. Malik, 14.9.1955. Sibi, soldiers, workers, coll. M. A. Malik, 19.9.1955.

16. *Microtermes sindensis* (Desneux)

Termes sindensis Desneux, 1906, p. 354 (imago).
Microtermes sindensis Holmgren, 1913b, p. 149, (imago). Snyder, 1949, p. 253 (synonymy).

IMAGO (Fig. 25) : Head dark brown ; antennae, pronotum and posterior

parts of meso- and metanota brown; postclypeus and the T-shaped median marking and the ocellus-like marking on each lateral corner of pronotum brownish yellow; tergites brown. Head with numerous long bristles and short hairs; tip of labrum with several bristles and hairs; postclypeus moderately hairy; pronotum as pubescent as the head. Head round. Eye of medium size, almost round, separated from the lower margin of the head by about half of its long diameter. Ocellus oval, one-and-a-half times as long as wide, separated from the eye by slightly less than its long diameter. Antenna with 15 articles, the second one and-a-half times as long as the third. Postclypeus strongly arched, nearly half as long as wide. Pronotum subcordate, slightly wider than the head, nearly one-and-a-half times as wide as long, indistinctly emarginate posteriorly, nearly straight anteriorly.

Fig. 25. *Microtermes sindensis* (Desneux), imago: Dorsal view of head and pronotum; and side view of head.

TABLE 26

Measurements (in mm.) of the imago of *Microtermes sindensis* (Desneux)

	No.	Range	Mean
Length of head to tip of labrum	10	1.66-1.81	1.77
Length of head to side base of mandibles	10	1.18-1.29	1.22
Width of head	10	1.38-1.49	1.42
Diameter of eye	10	0.29-0.34	0.32
Eye from lower margin of head	10	0.15-0.18	0.16
Length of ocellus	10	0.13-0.18	0.16
Width of ocellus	10	0.09-0.13	0.11
Ocellus from eye	10	0.13-0.16	0.14
Length of pronotum	10	0.92-0.99	0.94
Width of pronotum	10	1.40-1.51	1.46

DISTRIBUTION : Sukkur, imagoes, ex living *Dalbergia sisso*, coll. S. I. Hussain, 30. 7. 1954. Kotri (District Dadu), imagoes, swarming during day time, coll. S. I. Hussain, 5. 9. 1954.

Genus ***Microcerotermes*** Silvestri

KEY TO THE GENERA

IMAGOES

1. Ocellus very small, dot-like, separated from eye by twice its diameter ... ... *M. tenuignathus* Holmgren

   Ocellus larger, separated from eye by about its diameter ... ...

17. *Microcerotermes tenuignathus* Holmgren

Microcerotermes tenuignathus Holmgren, 1913a, pp. 116-117 (soldier, worker). Holmgren, 1913b, p. 257 (soldier, worker). Snyder, 1949, p. 147.

IMAGO (Fig. 26) : Head and pronotum dark brown ; labrum, postclypeus, antennae and abdominal tergites brown ; anteclypeus and the median line on pronotum white. Head moderately hairy, with long bristles and short hairs ; postclypeus and tip of the labrum with a few long bristles and short hairs; pronotum more hairy than the head. Head parallel sided, not narrowed anteriorly. Eye small, not bulging, round, separated from the lower margin of the head by about its diameter. Ocellus small, dot-like, separated from the eye by twice its diameter. Antenna with 14 articles, the second longer than the third and fourth combined, the third shortest. Postclypeus arched, half as long as wide. Anteclypeus more than twice as wide as long, slightly produced anteriorly. Labrum dome-shaped, wider than long. The left mandible with two widely separated marginal teeth, the cutting edge between the marginal teeth straight. The right mandible with two marginal teeth, the first marginal tooth long, pointed, the second marginal tooth small, round, posterior cutting edge elongate. Pronotum one-and-a-half times as wide as long, anterior margin slightly raised in the middle, indistinctly emarginate, posterior margin slightly depressed.

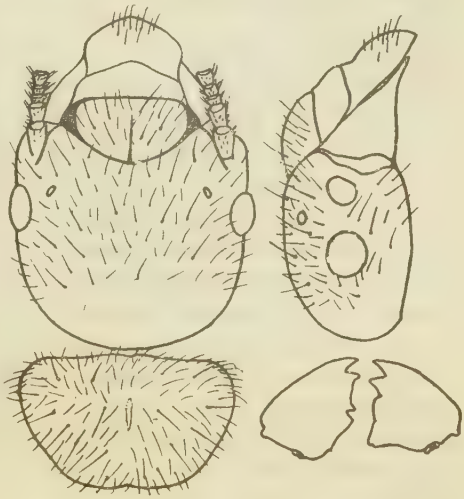


Fig. 26. *Microcerotermes tenuignathus* Holmgren, imago : Dorsal view of head and pronotum ; side view of head ; and mandibles.

TABLE 27

Measurement (in mm.) of the imago of *Microcerotermes tenuignathus* Holmgren

	No.	Range	Mean
Length of head to tip of labrum	21	1.01-1.17	1.10
Length of head to side base of mandibles	24	0.77-0.84	0.81
Width of head	24	0.83-0.93	0.85

	No.	Range	Mean
Long diameter of eye	17	0.18-0.21	0.19
Short diameter of eye	17	0.17-0.18	0.17
Eye from lower margin of head	17	0.14-0.16	0.15
Diameter of ocellus	24	0.05-0.06	0.05
Ocellus from eye	17	0.09-0.12	0.10
Length of pronotum	25	0.44-0.48	0.45
Width of pronotum	25	0.64-0.76	0.72

SOLDIER (Fig. 27) : Head yellow ; mandibles light reddish brown ; labrum and antennae brownish yellow; rest of the body pale. Head with a few scattered long bristles and short hairs ; tip of labrum with a few hairs ; a few hairs at the tip of postmentum ; pronotum with a few long bristles along the lateral margins, and short hairs in other parts. Head elongate, slightly narrowed anteriorly, sides slightly convex. Postmentum widest in the anterior half, about twice as wide as long. Antenna with 13 articles, the second slightly longer than the third, the fourth and the third nearly subequal. Anteclypeus trapezoid, more than twice as wide as long. Labrum almost as long as wide, narrowly curved at tip, antero-lateral sides converging anteriorly, postero-lateral sides parallel. Madibles thin, curved, indistinctly serrate. Pronotum saddle-shaped, about twice as wide as long, indistinctly emarginate anteriorly and posteriorly.

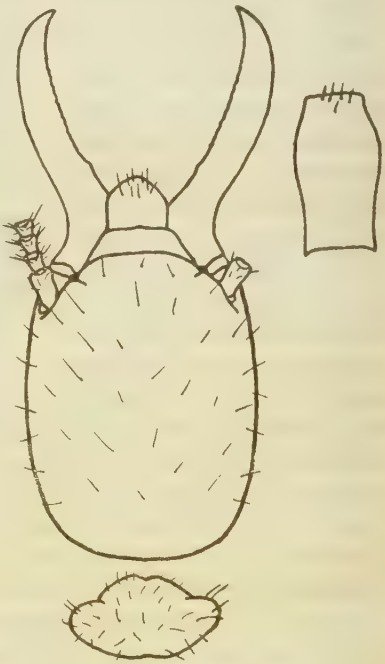


Fig. 27. *Microcerotermes tenuignathus* Holmgren, soldier : Dorsal view of head and pronotum ; and ventral view of postmentum.

TABLE 28

Measurements (in mm.) of the soldier of *Microcerotermes tenuignathus* Holmgren

	No.	Range	Mean
Length of head with mandibles	10	1.97-2.03	1.99
Length of head to side base of mandibles	10	1.10-1.20	1.15
Width of head	10	0.77-0.81	0.79

	No.	Range	Mean
Length of postmentum	6	0.60-0.62	0.62
Width of postmentum	8	0.30-0.32	0.30
Length of pronotum	8	0.25-0.30	0.28
Width of pronotum	10	0.55-0.59	0.58

REMARKS : This species was described by Holmgren from the soldier caste alone. The winged caste has hitherto been unknown. The description and the measurements of the soldiers match very well with Holmgren's description and measurements of *Microcerotermes tenuignathus*. The soldier of *M. heimi* is slightly larger and has less curved mandibles.

DISTRIBUTION : Sukkur, imagoes, ex roots of bushes in sand, coll. S. I. Hussain, 30.7.1954. Sukkur, soldiers, ex roots of bushes in sand, coll. S. I. Hussain, 4.9.1954. Kotri (District Dadu), imagoes, coll. S. I. Hussain, 5.9.1954. Usta Muhammad (District Sibi), 2 imagoes, 3 soldiers, ex *Acacia arabica*, coll. M. A. Malik, 11.9.1954.

18. *Microcerotermes heimi* Wasmann

Microcerotermes heimi Wasmann, 1902, p. 120 (imago, soldier). Holmgren 1913b, p. 260 (imago, soldier, worker). Holmgren, 1913-14, p. 285 (imago, soldier, worker). Holmgren, K. & N., 1917, p. 171 (location). Snyder, 1949, p. 140.

IMAGO (Fig. 28): Head light brown; labrum, postclypeus, antennae, and pronotum yellow; fontanelle whitish. Head with a few long bristles and short hairs; labrum with a few bristles at the tip; postclypeus with a few bristles and short hairs; pronotum more pubescent than the head, with numerous long bristles and short hairs. Head parallel sided, not narrowed anteriorly. Fontanelle small, round, situated a little above the level of the lower margin of eyes. Eye of medium size, not quite round, separated from the lower margin of the head by three-fourths of its long diameter. Ocellus broadly oval,

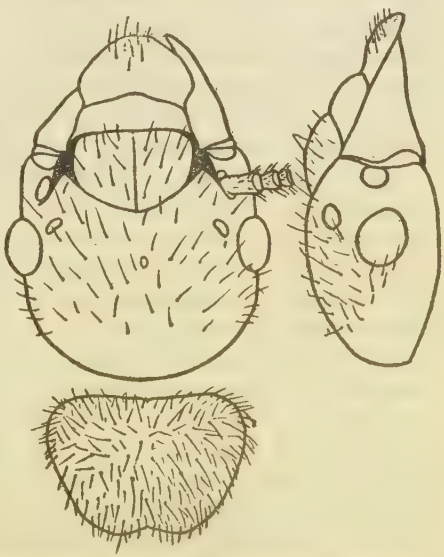


Fig. 28. *Microcerotermes heimi* Wasmann, imago : Dorsal view of head and pronotum; and side view of head.

only slightly longer than broad, separated from the eye by its long diameter. Antenna with 14 articles, the second as long as the third and fourth combined, the third shortest. Postclypeus strongly arched, more than half as long as wide. Pronotum about one-and-a-half times as wide as long, anterior margin almost straight, posterior margin distinctly emarginate.

TABLE 29

Measurements (in mm.) of the imago of *Microcerotermes heimi* Wasmann

	No.	Range	Mean
Length of head to tip of labrum	10	1.07-1.13	1.11
Length of head to side base of mandibles	19	0.75-0.82	0.78
Width of head	20	0.85-0.92	0.88
Long diameter of eye	20	0.19-0.21	0.20
Short diameter of eye	20	0.16-0.17	0.16
Eye from lower margin of head	20	0.11-0.13	0.12
Length of ocellus	20	0.07-0.10	0.09
Width of ocellus	20	0.06-0.07	0.07
Ocellus from eye	20	0.08-0.10	0.09
Length of pronotum	22	0.37-0.45	0.42
Width of pronotum	22	0.65-0.75	0.72

SOLDIER (Fig. 29): Head brownish yellow ; slightly darker anteriorly, antennae light brown ; pronotum of the same colour as the posterior part of the head. Head with a few scattered bristles and short hairs; tip of labrum with a few bristles ; postmentum with a few bristles at the tip ; pronotum with a few long bristles along the lateral and postero-lateral margins, short hairs in other parts. Head elongate, only slightly narrowed anteriorly, sides slightly convex. Postmentum widest about the middle, about twice as long as wide. Antenna with 13 articles, the second one-and-a-half times as long as the fourth, the third shortest. Labrum short, broadly curved anteriorly, postero-lateral sides almost parallel. Mandibles shorter than the head capsule, slightly curved at tip, outer margin slightly convex, inner margin very finely serrate. Pronotum saddle-shaped, one-and-a-half times as wide as long, anterior margin not emarginate, posterior margin depressed in the middle.

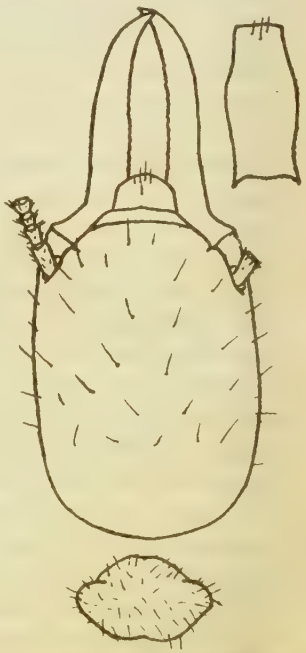


Fig. 29. *Microcerotermes heimi* Wasmann, soldier : Dorsal view of head and pronotum ; and ventral view of postmentum.

TABLE 30

Measurements (in mm.) of the soldier of *Microcerotermes heimi* Wasmann

	No.	Range	Mean
Length of head with mandibles	11	2.10-2.20	2.14
Length of head to side base of mandibles	15	1.21-1.30	1.25
Width of head	14	0.86-0.94	0.88
Length of postmentum	10	0.63-0.68	0.64
Width of postmentum	14	0.30-0.35	0.33
Length of pronotum	14	0.28-0.34	0.31
Width of pronotum	14	0.52-0.61	0.56

REMARKS : The imagoes and soldiers of this species were compared with cotype by Dr Alfred E. Emerson, and found to be conspecific with it. According to him (personal communication) Holmgren's description of *Microcerotermes heimi*, as given in his monograph of oriental termites (1913b), does not compare with cotype. Probably he had before him some other species which he indentified as *heimi* without comparing it with type specimens. *M. heimi* soldier is larger than *M. tenuignathus* and has less curved mandibles.

19. *Microcerotermes baluchistanicus* n. sp.

IMAGO (Fig. 30) : Head light brown ; postclypeus yellow; antennae light brownish yellow ; rest of the body yellow. Head rather sparsely hairy, with a few long bristles and short hairs ; postclypeus with a few long bristles and short hairs ; tip of labrum with a few bristles ; pronotum moderately pubescent, with long bristles and short hairs. Head not narrowed anteriorly, parallel sided. Eye small, not quite round, slightly longer than wide, separated from the lower margin of the head by slightly less than three-fourths of its long

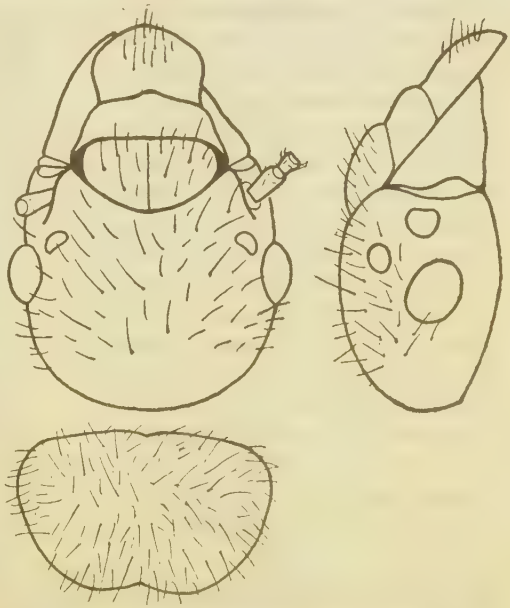


Fig. 30. *Microcerotermes baluchistanicus* n. sp., imago : Dorsal view of head and pronotum ; and side view of head.

diameter. Ocellus rather large, round, separated from the eye by its diameter. Antenna with 13 articles, the second one-and-a-half times as long as the third. Postclypeus arched, less than half as long as wide. Anteclypeus short, three times as wide as long, slightly produced anteriorly. Labrum wider than long, dome-shaped. Pronotum slightly less than one-and-a-half times as wide as long, anterior margin convex, with indistinct notch in the middle, posterior margin distinctly emarginate.

MEASUREMENTS (in mm.) : Length of head to tip of labrum 1.09 ; length of head to side base of mandibles 0.79 ; width of head 0.84 ; long diameter of eye 0.20 ; short diameter of eye 0.16 ; eye from the lower margin of head 0.13 ; diameter of ocellus 0.09 ; ocellus from eye 0.09 ; length of pronotum 0.42 ; width of pronotum 0.77.

SOLDIER (Fig. 31) : Head brownish yellow ; mandibles light reddish brown ; labrum light brown ; rest of the body yellow. Head sparsely hairy, with only a few scattered bristles and short hairs ; labrum and postmentum with a few bristles at the tip ; pronotum moderately hairy, with a few long bristles along the lateral margins, and more numerous short hairs on other parts. Head oblong, thick, slightly narrowed anteriorly, sides slightly convex. Postmentum twice as long as wide, widest about the middle. Antenna with 13 articles, the second one-and-a-half times as long as the third. Labrum short, broadly curved apically, postero-lateral sides almost parallel. Mandibles curved in the distal half, indistinctly serrate, the basal third with a rather prominent denticle. Pronotum saddle-shaped, about one-and-a-half times as wide as long, indistinctly emarginate anteriorly and posteriorly.

Fig. 31. *Microcerotermes baluchistanicus* n. sp., soldier : Dorsal view of head and pronotum ; and ventral view of postmentum.

TABLE 31

Measurements (in mm.) of the soldier of *Microcerotermes baluchistanicus* n. sp.

	No.	Range	Mean
Length of head with mandibles	6	1.83-2.22	2.01

	No.	Range	Mean
Length of head to side base of mandibles	6	1.11-1.29	1.17
Width of head	6	0.96-0.99	0.96
Length of postmentum	6	0.74-0.77	0.75
Width of postmentum	6	0.29-0.33	0.30
Length of pronotum	6	0.33	0.33
Width of pronotum	6	0.55-0.59	0.57

COMPARISONS : The imago of *Microcerotermes baluchistanicus* comes close to the imago of *M. heimi* and *M. beesoni* Snyder, from which it can be distinguished by its round and slightly larger ocelli, antenna with 13 articles, and proportionately wider pronotum. The soldier differs from *M. heimi*, and *M. tenuignathus* in its proportionately wider head.

TYPE LOCALITY : Fort Sandeman (Dist. Zhob in the former province of Baluchistan), one imago (morphotype), six soldiers (holotype and paratypes), workers, ex living apricot tree, coll. M. A. Malik, 20.8.1955.

20. ***Microcerotermes championi*** Snyder

Microcerotermes championi Snyder, 1933b, pp. 14-15 (imago, soldier). Snyder, 1949, p. 136.

IMAGO (Fig. 32) : Head, pronotum and abdominal tergites brown; postclypeus and antennae light brown ; the median line on the pronotum brownish yellow. Head moderately pubescent ; postclypeus and tip of labrum with a few bristles and short hairs; pronotum rather densely hairy. Head parallel sided, not narrowed anteriorly. Fontanelle very small, dot-like, located slightly above the level of the lower margin of eyes. Eye of medium size, slightly longer than wide, separated from the lower margin of the head by less than its short diameter. Ocellus of medium size, oval, separated from the eye by its short diameter. Antenna with 14 articles, the second as long as the third and fourth combined, the

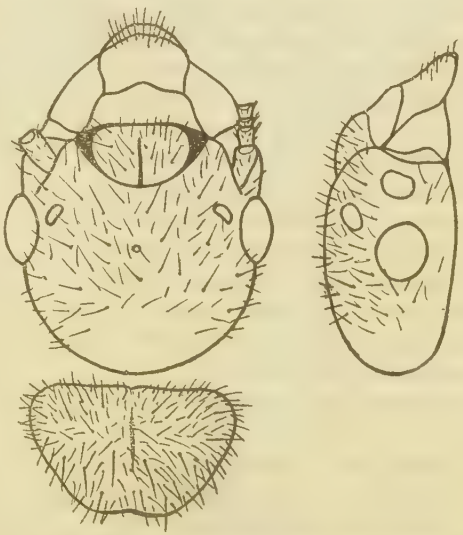


Fig. 32. *Microcerotermes championi* Snyder, imago : Dorsal view of head and pronotum ; and side view of head.

third shortest. Postclypeus arched, slightly less than half as long as wide. Pronotum one-and-a-half times as wide as long, anterior side almost straight, posterior margin emarginate.

TABLE 32

Measurements (in mm.) of the imago of *Microcerotermes championi* Snyder

	No.	Range	Mean
Length of head to tip of labrum	10	1.04-1.15	1.07
Length of head to side base of mandibles	10	0.76-0.83	0.79
Width of head	10	0.83-0.90	0.87
Long diameter of eye	10	0.20-0.21	0.20
Short diameter of eye	10	0.16-0.18	0.17
Eye from lower margin of head	10	0.12-0.15	0.14
Length of ocellus	10	0.09-0.10	0.09
Width of ocellus	10	0.72	0.72
Ocellus from eye	10	0.72	0.72
Length of pronotum	10	0.46-0.49	0.48
Width of pronotum	10	0.67-0.71	0.70

SOLDIER (Fig. 33): Head reddish brown; mandibles dark brown; labrum, antennae and pronotum brownish yellow; rest of the body pale. Head sparsely hairy; labrum with 3 to 4 long bristles at the tip; postmentum with two bristles at the tip; pronotum sparsely hairy. Head elongate, parallel sided, very slightly narrowed anteriorly. Postmentum more than three times as long as wide, widest in the apical third. Antenna with 13 articles, the second slightly shorter than the third and fourth combined, the third shortest. Mandibles stoutly built, coarsely serrate, moderately curved, sickle-shaped. Pronotum saddle-shaped, about twice as wide as long, distinctly notched anteriorly, posterior margin faintly depressed in the middle.

Fig. 33. *Microcerotermes championi* Snyder, soldier: Dorsal view of head and pronotum; and ventral view of postmentum.

TABLE 33

Measurements (in mm.) of the soldier of *Microcerotermes championi* Snyder

	No.	Range	Mean
Length of head with mandibles	5	2.40-2.50	2.49
Length of head to side base of mandibles	7	1.40-1.50	1.43
Width of head	7	0.87-0.95	0.90
Length of postmentum	7	0.75-0.87	0.82
Width of postmentum	7	0.29-0.33	0.30
Length of pronotum	7	0.30-0.37	0.33
Width of pronotum	7	0.57-0.65	0.60

DISTRIBUTION : Kotri (District Dadu), 2 soldiers, workers, ex *Acacia arabica*, coll. S. I. Hussain, 17.7.1954. Hyderabad, imagoes, 3 soldiers, workers, ex living *Acacia arabica*, coll. S. I. Hussain, 17.7.1954. Larkana 2 soldiers, workers, ex *Acacia arabica*, coll. S. I. Hussain, 28.7.1954.

21. *Microcerotermes sakesarensis* n. sp.

SOLDIER : (Fig. 34) : Head brownish yellow ; antennae light brownish yellow ; mandibles dark reddish brown ; rest of the body yellow. Head sparsely hairy ; tip of labrum with four bristles ; pronotum slightly more densely hairy than the head. Head elongate, sides almost parallel, a little more than one-and-a-half times as long as wide. Postmentum slightly less than three times as long as wide, widest in the apical third. Antenna with 13 articles, the second as long as the third and fourth combined, the third shortest. Labrum nearly as long as wide, narrowly curved apically, postero-lateral sides parallel. Mandibles stoutly built, shorter than the head capsule, strongly hooked, coarsely serrate. Postmentum slightly less than twice as

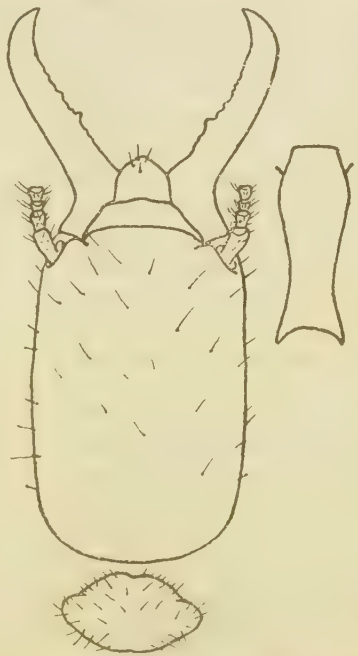


Fig 34. *Microcerotermes sakesarensis* n. sp., soldier : Dorsal view of head and pronotum ; and ventral view of postmentum.

wide as long, indistinctly emarginate anteriorly and posteriorly.

TABLE 34

Measurements (in mm.) of the soldier of *Microcerotermes sakesarensis* n. sp.

	No.	Range	Mean
Length of head with mandibles	4	2.29-2.55	2.36
Length of head to side base of mandibles	4	1.48-1.58	1.54
Width of head	4	0.81-0.95	0.90
Length of postmentum	4	0.81-0.88	0.83
Width of postmentum	4	0.29	0.29
Length of pronotum	4	0.29-0.33	0.31
Width of pronotum	4	0.55-0.59	0.56

COMPARISONS : Close to *Microcerotermes championi*, but has strongly hooked mandibles and pronotum indistinctly notched anteriorly.

TYPE LOCALITY : Sakesar (Districtct Sargodha), soldiers (holotype, paratypes), workers, ex dead Pine tree, coll. M. Ahmad and M. Saleem, April, 1955.

22. ***Microcerotermes longignathus*** n. sp.

SOLDIER (Fig. 35) : Head and labrum brownish yellow ; mandibles dark reddish brown, lighter at the base; pronotum yellow; rest of the body pale. Head with a few scattered bristles and short hairs ; labrum with a few bristles in the anterior half ; postmentum with a few bristles at the tip and short hairs in the anterior half ; pronotum slightly more densely hairy than the head. Head elongate, about three-fourths as wide as long. Postmentum twice as long as wide, widest in the middle. Antenna with 13 articles, the second as long as the fourth, the third shortest. Anteclypeus very short, trapezoid, slightly produced anteriorly in the middle. Labrum about as long as wide, tip narrowly rounded, postero-

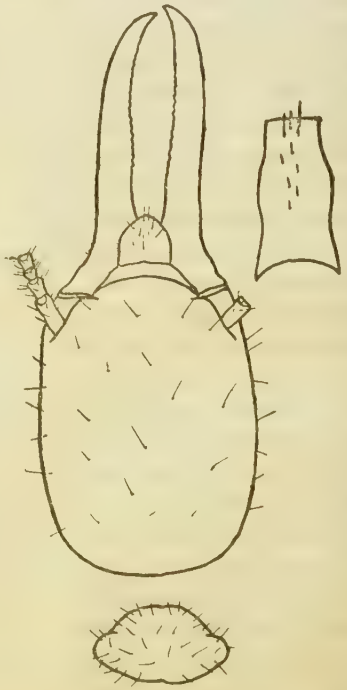


Fig. 35. *Microcerotermes longignathus* n. sp., soldier : Dorsal view of head and pronotum ; and ventral view of postmentum.

lateral sides parallel. Mandibles longer than the head, straight except the slightly curved tip, very finely serrate. Pronotum saddle-shaped, almost twice as wide as long, indistinctly emarginate anteriorly and posteriorly.

TABLE 35

Measurements (in mm.) of the soldier of *Microcerotermes longignathus* n. sp.

	No.	Range	Mean
Length of head with mandibles	7	2.18-2.36	2.25
Length of head to side base of mandibles	7	1.14-1.25	1.17
Width of head	7	0.88-0.96	0.92
Length of postmentum	5	0.66	0.66
Width of postmentum	5	0.30-0.33	0.32
Length of pronotum	7	0.29-0.33	0.30
Width of pronotum	7	0.55-0.59	0.56

COMPARISONS : Close to *Microcerotermes heimi* and *M. tenuignathus*, but has proportionately longer mandibles.

TYPE LOCALITY : Fort Sandeman (District Zhob), 7 soldiers (holotype, paratypes), ex living apricot tree, coll. M. A. Malik, 2.8.1955.

Genus ***Eremotermes*** Silvestri

KEY TO THE SPECIES

SOLDIERS

1. Large species ; length of head with mandibles 2.01-2.07 mm. ... ... *E. maliki* n. sp.

   Small species ; length of head with mandibles 1.62-1.72 mm... 2

2. Tooth on the mandibles situated in the middle ; mandibles longer than head ... ...*E. neoparadoxalis* n. sp.

   Tooth on the mandibles more anteriorly located ; mandibles as long as head ... ... *E. paradoxalis* Holmgren

23. ***Eremotermes paradoxalis*** Holmgren

Eremotermes paradoxalis Holmgren, 1912, p. 95 (soldier). Holmgren, 1913a, pp. 115-116 (soldier, worker). Holmgren, 1913b, p. 232 (soldier). Holmgren K. & N., 1917, p. 166 (imago). Snyder, 1949, p. 132.

IMAGO (Fig. 36) : Head light brown to dark brown ; labrum, postclypeus and antennae light brownish yellow to brown ; pronotum brownish yellow to brown ; meso- and metanota pale. Head and pronotum moderately hairy. Head more or less round. Fontanelle narrow, slit-like. Eye small, not quite round, separated from the lower margin of the head by slightly more than half of its long diameter. Ocellus broadly oval, separa-

ted from the eye by half of its long diameter. Antenna with 15 articles, the second almost as long as the third and fourth combined, the third shortest. Postclypeus moderately arched, nearly twice as wide as long. The left mandible with two widely separated marginal teeth, the second marginal tooth very small, round, the edge between the marginal teeth almost straight; the right mandible with two prominent marginal teeth, the posterior cutting edge of the second marginal tooth concave. Pronotum nearly one-and-a-half times as wide as long, with a T-shaped median marking, some specimens with a straight median marking, slightly emarginate anteriorly and posteriorly.

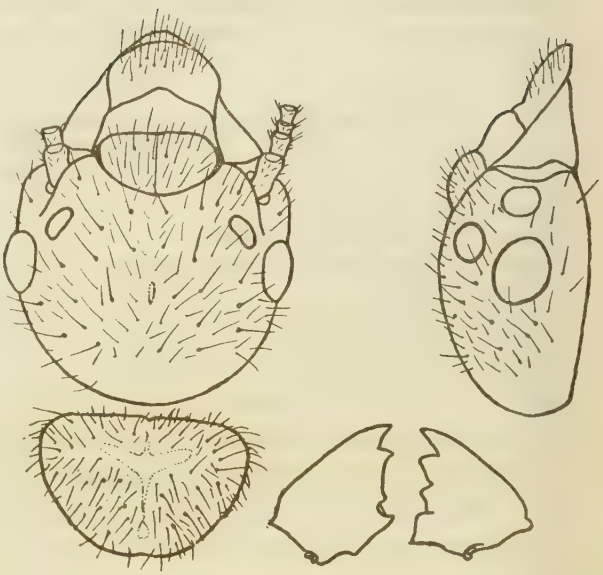


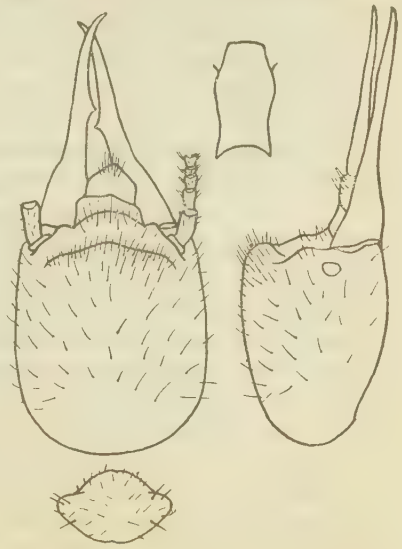
Fig. 36. *Eremotermes paradoxalis* Holmgren, imago: Dorsal view of head and pronotum; side view of head; and mandibles.

TABLE 36

Measurements (in mm.) of the imago of *Eremotermes paradoxalis* Holmgren

	No.	Range	Mean
Length of head to tip of labrum	8	1.00-1.07	1.03
Length of head to side base of mandibles	15	0.68-0.75	0.71
Width of head	15	0.76-0.86	0.80
Length of eye	15	0.18-0.23	0.20
Width of eye	15	0.16-0.20	0.18
Eye from lower margin of head	15	0.08-0.12	0.10
Length of ocellus	15	0.07-0.12	0.09
Width of ocellus	15	0.07-0.10	0.08
Ocellus from eye	15	0.04-0.06	0.04
Length of pronotum	15	0.34-0.43	0.37
Width of pronotum	15	0.60-0.72	0.63

SOLDIER (Fig. 37) : Head light reddish brown ; mandibles light brown in the basal third, reddish brown in the outer two-thirds ; antennae brownish yellow ; pronotum a shade lighter than the head. Head moderately hairy, frontal projection with numerous long bristles and short hairs ; tip of labrum with a few bristles ; pronotum with a few long bristles along the margins, and short hairs in the middle. Head subrectangular, sides slightly converging anteriorly, widest in the posterior half; frontal projection l o w . Postmentum broadest a little anterior to the middle. Antenna with 13 articles, the second one-and-a-half times as long as the third, the fourth shortest. Labrum one-and-a-half times as wide as long, antero-lateral sides converging anteriorly into a pointed tip, postero-lateral sides parallel. Mandibles long, slender, base broad and thick, tip slightly curved; outer margin depressed below ths middle ; the left mandible with a small, sharply pointed tooth beyond the middle ; the right mandible with a similar tooth at a slightly lower level. Pronotum saddle-shaped, one-and-a-half times as wide as long, indistinctly emarginate anteriorly and posteriorly.



Fig, 37. *Eremotermes paradoxalis* Holmgren, soldier : Dorsal view of head and pronotum ; ventral view of postmentum ; and side view of head.

TABLE 37

Measurements (in mm.) of the soldier of *Eremotermes paradoxalis* Holmgren

	No.	Range	Mean
Length of head with mandibles	5	1.62-1.72	1.66
Length of head to side base of mandibles	9	0.80-0.88	0.86
Width of head	9	0.71-0.78	0.74
Length of postmentum	9	0.37-0.42	0.40
Width of postmentum	9	0.25-0.28	0.26
Length of pronotum	9	0.25-0.32	0.26
Width of pronotum	9	0.43-0.46	0.45

DISTRIBUTION : Lahore, imagoes, at light, coll. M. Ahmad, 7.8.1951. Lahore, soldiers, workers, ex mound of *Odontotermes obesus*, coll. M. A. Khan, 17.7.1952. Abbottabad, imagoes, emerging in the morning from a hole in a grassy plot, after a shower of rain, coll. Ghulamullah, 22.6.1953. Dadu, soldiers, workers, ex cow dung, coll. S. I. Hussain, 16.7.1964. Kohat, imagoes, at light, coll. Fazle Majid Khan, 18.7.1954. Sialkot, imagoes, ex mound of *Odontotermes*, coll. N. A. Bashir, 20.7.1954. Kotri (District Dadu), 2 imagoes, at light, coll. S. I. Hussain, 5.9.1954.

24. *Eremotermes neoparadoxalis* n. sp.

SOLDIER (Fig. 38) : Head, labrum and pronotum brownish yellow ; mandibles brownish yellow in the basal third, light reddish brown in the outer two-thirds ; rest of the body yellow. Head scantily hairy, with a few scattered long bristles and short hairs ; frontal projection more densely hairy than the head ; tip of labrum with a few bristles ; pronotum sparsely hairy, a few bristles on the lateral margins and short hairs in the middle. Head subrectangular, slightly narrowed anteriorly, widest about the middle ; frontal projection very low. Postmentum slightly more than one-and-a-half times as long as wide, widest in the anterior half. Antenna with 13 articles, the second slightly longer than the third, the fourth shortest. Labrum about as long as wide, antero-lateral sides converging anteriorly into a pointed tip, postero-lateral sides parallel. Mandibles long, slender, base broad and thick, tip slightly bent, outer margin depressed a little below the middle ; the left mandible with a minute tooth about the middle ; right mandible with a similar tooth in about the same position. Pronotum saddle-shaped,

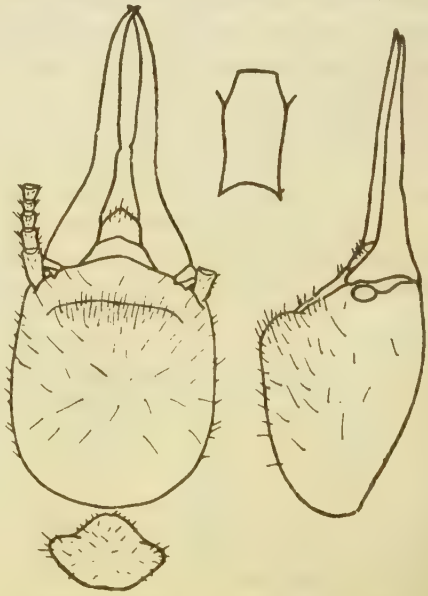


Fig. 38. *Eremotermes neoparadoxalis* n. sp., soldier : Dorsal view of head and pronotum ; ventral view of postmentum; and side view of head.

with a large triangular anterior lobe, indistinctly emarginate anteriorly and posteriorly.

TABLE 38

Measurements (in mm.) of the soldier of *Eremotermes neoparadoxalis* n. sp.

	No.	Range	Mean
Length of head with mandibles	3	1.66-1.77	1.70
Length of head to side base of mandibles	4	0.77-0.82	0.79
Width of head	4	0.74-0.77	0.76
Length of postmentum	3	0.44	0.44
Width of postmentum	4	0.23-0.25	0.24
Length of pronotum	4	0.19-0.26	0.23
Width of pronotum	4	0.40-0.44	0.42

COMPARISONS : Close to *Eremotermes paradoxalis* in size, from which it can be distinguished by its smaller and more posteriorly placed denticle on mandibles, and less prominent frontal projection. *E. fletcheri* Holmgren, K. & N., the only other hitherto known species of the genus from the Indo-Pakistan sub-continent is much larger.

TYPE LOCALITY : Shahdadpur, 4 soldiers (holotype, paratypes), workers, coll. S. I. Hussain, 18.8.1954.

25. *Eremotermes maliki* n. sp.

SOLDIER (Fig. 39): Head yellow; mandibles brownish yellow in the basal fourth, light reddish brown in the outer three-fourths ; labrum and antennae light brownish yellow; rest of the body pale. Head with scattered bristles and short hairs ; hairs around frontal projection rather dense ; tip of labrum with a few bristles ; pronotum with a few long bristles on the lateral and postero-lateral margins, short hairs in the middle. Head oblong, slightly narrowed anteriorly, sides moderately convex ; frontal projection not prominent. Postmentum twice as long as wide. Antenna with 14 articles, the second a little longer than the third ; the fourth shorter than the third. Anteclypeus short, trapezoid

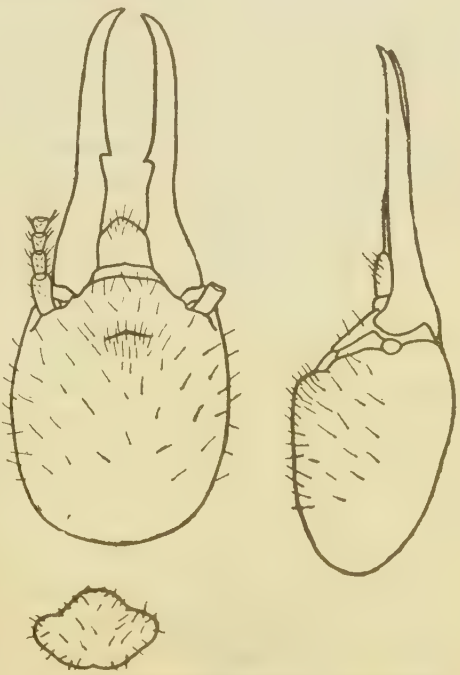


Fig. 39. *Eremotermes maliki* n. sp., soldier: Dorsal view of head and pronotum ; and side view of head.

Labrum about as long as wide, antero-lateral margins converging into an obtusely angled tip, postero-lateral sides parallel. Mandibles long, with broad base and slightly bent tip, with a distinct posteriorly directed tooth placed in the middle, inner margin deeply notched at the base of the tooth. Pronotum saddle-shaped, twice as wide as long, anterior margin not emarginate, posterior margin slightly medially depressed.

TABLE 39

Measurements (in mm.) of the soldier of *Eremotermes maliki* n. sp.

	No.	Range	Mean
Length of head with mandibles	5	2.01-2.07	2.04
Length of head to side base of mandibles	6	0.94-1.03	0.99
Width of head	6	0.81-0.85	0.84
Length of postmentum	4	0.51-0.59	0.54
Width of postmentum	4	0.25-0.29	0.27
Length of pronotum	5	0.22-0.25	0.23
Width of pronotum	5	0.44-0.51	0.48

COMPARISONS : Can be distinguished from *Eremotermes fletcheri* by its proportionately longer mandibles with more posteriorly situated tooth.

TYPE LOCALITY : Duki (District Loralai), six soldiers (hototype, paratypes) and several workers, under a stone, collected on 18.8.1955 by Muhammad Anwar Malik in whose honour it is named.

Genus ***Amitermes*** Silvestri

KEY TO THE SPECIES

SOLDIERS

Mandibles proportionately longer, with a sharp and posteriorly directed tooth situated a little below the middle... ... ... *A. belli* (Desneux)

Mandibles proportionately shorter, with a blunt and laterally directed tooth placed a little anterior to the middle ... ... *A. paradentatus* n. sp.

26. ***Amitermes belli*** (Desneux)

Termes Belli Desneux, p. 352 (imago, soldier, worker).
Hamitermes (H.) Belli Holmgren, 1912, p. 93. Holmgren, 1913b, p. 227 (imago, soldier, worker).
Amitermes belli Snyder, 1949, p. 114 (synonymy).

IMAGO (Fig. 40) : Head, pronotum and abdominal tergites brown ;

labrum, postclypeus, antennae and legs brownish yellow ; fontanelle and the T-shaped median marking on the pronotum pale ; wings smoky brown. Head densely hairy, with long bristles and short hairs ; postclypeus with a few long bristles and more numerous short hairs ; labrum with bristles and hairs in the anterior half ; pronotum as hairy as the head. Head round. Fontanelle elongately oval. Eye of medium size, round, slightly bulging, separated from the lower margin of the head by nearly half of its diameter. Ocellus broadly oval, about one-and-a-half times as long as wide, separated from the eye by its short diameter. Antenna with 15 articles, the second as long as the third and fourth combined, the third shortest. Postclypeus nearly half as long as wide, with a faint median line. Labrum wider than long, lateral corners prominent, anterior margin convex. The left mandible with only one marginal tooth, the other represented by the broadly curved lower end of the posterior cutting edge of the first marginal tooth. The right mandible with two marginal teeth. Pronotum subcordate, one-and-a-half times as wide as long, anterior margin slightly raised in the middle with an indistinct notch, posterior margin slightly emarginate.

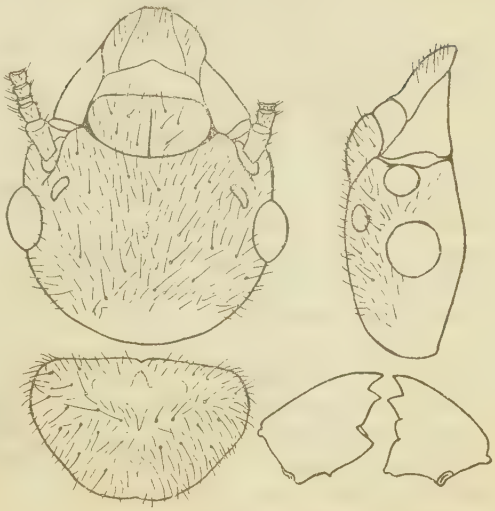


Fig. 40. *Amitermes belli* (Desneux), imago : Dorsal view of head and pronotum ; side view of head ; and mandibles.

TABLE 40

Measurements (in mm.) of the imago of *Amitermes belli* (Desneux)

	No.	Range	Mean
Length of head to tip of labrum	16	1.04-1.15	1.09
Length of head to side base of mandibles	18	0.74-0.81	0.76
Width of head	18	0.94-1.06	1.01
Diameter of eye	10	0.21-0.25	0.22
Eye from lower margin of head	10	0.09-0.12	0.10
Length of ocellus	10	0.10-0.14	0.12
Width of ocellus	10	0.07-0.09	0.08
Ocellus from eye	10	0.07-0.09	0.08

	No.	Range	Mean
Length of pronotum	18	0.48-0.58	0.53
Width of pronotum	18	0.71-0.89	0.85

SOLDIER (Fig. 41) : Head yellow ; mandibles brownish yellow at the base, light reddish brown in the outer two-thirds ; proximal articles of the anntennae, and pronotum brownish yellow; distal articles of the antennae light brown ; labrum and anteclypeus pale. Head with a few scattered bristles and short hairs ; frontal projection densely hairy ; tip of labrum with a few bristles ; postmentum with two to three bristles at the anterior end ; pronotum scantily hairy. Head thick, oblong, slightly narrowed anteriorly, widest in the posterior half. Postmentum arched, two-and-a-half times as long as wide, widest in the anterior third. Antenna with 14 articles, the second one-and-a-half times as long as the third, the fourth shortest. Anteclypeus bilobed, each lobe dome-shaped. Labrum dome-shaped, slightly wider than long. Mandibles thin, sickle-shaped, base broad and thick, tip curved ; a prominent, sharply pointed, posteriorly directed tooth in the middle of each mandible. Pronotum saddle-shaped, about one-and-a-half times as wide as long, indistinctly emarginate anteriorly and posteriorly.

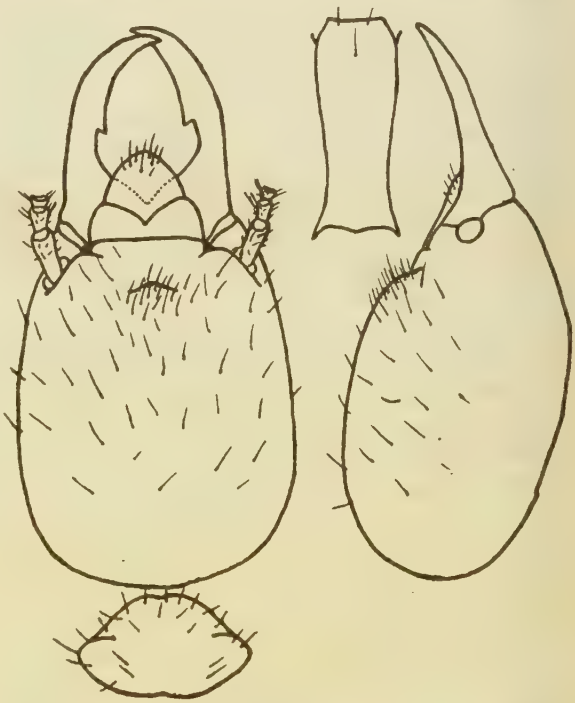


Fig. 41. *Amitermes belli* (Desneux), soldier: Dorsal view of head and pronotum ; ventral view of postmentum ; and side view of head.

TABLE 41

Measurements (in mm.) of the soldier of *Amitermes belli* (Desneux)

	No.	Range	Mean
Length of head with mandibles	27	1.77-2.16	1.96
Length of head to side base of mandibles	28	1.24-1.44	1.30
Width of head	31	1.00-1.14	1.06
Length of postmentum	30	0.70-0.90	0.82
Width of postmentum	32	0.28-0.35	0.31
Length of pronotum	26	0.30-0.44	0.39
Width of pronotum	30	0.56-0.68	0.64

DISTRIBUTION : Lahore, soldiers, workers, coll. M. Ahmad and M. A. Khan. Kotri (District Dadu), soldiers, workers, ex living *Acacia arabica*, coll. S. I. Hussain, 8.7.1954. Lyallpur, imagoes, soldiers, workers, attacking roots of *Dalbergia sisso*, coll. N.A. Bashir, 31.7.1954. Sukkur, imagoes, soldiers, workers, ex mound on the bank of river Indus, coll. S. I. Hussain, 31.7.1954. Larkana, imagoes, soldiers, workers, ex *Acacia arabica*, coll. S.I. Hussain, 4.8.1954. Chichawatni Forests (District Montgomery), soldiers, workers, coll. N. A. Bashir, 8.8.1954. Montgomery, soldiers, workers ex *Acacia arabica*, coll. N. A. Bashir, 18.8.1954. Mianwali, soldiers, workers, ex roots of a green *Acacia arabica*, coll. N. A. Bashir, 7.11.1954. Multan, soldiers, workers, ex *Acacia arabica*, coll. N. A. Bashir, 8.11.1954. Sibi, soldiers, workers, coll. M. A. Malik, 18.7.55. Jhat Pat (District Sibi), soldiers, workers, coll. M. A. Malik, 4.9.1955.

27. *Amitermes paradentatus* n. sp.

SOLDIER (Fig. 42) : Head, antennae and pronotum brownish yellow ; labrum and anteclypeus yellow ; mandibles brownish yellow in the basal third, reddish brown in the outer two-thirds. Head with a few scattered bristles, frontal projection with numerous hairs ; tip of labrum with a few bristles in the anterior half ; pronotum scantily hairy. Head thick, narrowed anteriorly, widest in the posterior half ; frontal projection not prominent. Postmentum arched, about twice as long as wide, widest in the anterior third. Antenna with 14 articles, the second one-and-a-half times as long as the third, the fourth slightly longer than the third. Anteclypeus bilobed, lobe dome-shaped. Labrum dome-shaped, about as wide as long. Mandibles stout, base broad and

thick, tip pointed, bent; a prominent, rather blunt, laterally directed tooth a little anterior to the middle on the inner margin of each mandible. Pronotum saddle-shaped, twice as wide as long, weakly emarginate anteriorly and posteriorly.

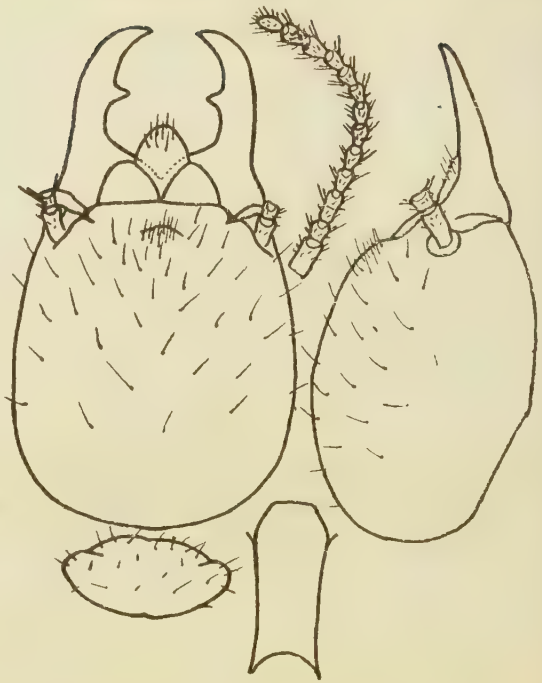


Fig. 42. *Amitermes paradentatus* n. sp., soldier: Dorsal view of head and pronotum; antenna; side view of head; and ventral view of postmentum.

TABLE 42

Measurements (in mm.) of the soldier of *Amitermes paradentatus* n. sp.

	No.	Range	Mean
Length of head with madibles	4	1.75-1.80	1.77
Length of head to side base of mandibles	6	1.23-1.39	1.30
Width of head	6	0.92-1.03	0.98
Length of postmentum	6	0.55-0.65	0.61
Width of postmentum	7	0.30-0.37	0.32
Length of pronotum	6	0.28-0.34	0.30
Width of pronotum	6	0.59-0.66	0.63

COMPARISONS: Differs from *Amitermes belli*, the only other species of the genus hitherto known from the Indo-Pakistan sub-continent in having shorter and more stoutly built mandibles with laterally directed tooth situated about the middle. *A. dentatus* (Haviland), from Malaya, Sumatra and Borneo, resembles the new species in the shape and position of the tooth on the mandibles, but has differently shaped mandibles and is larger

in size. *A. minor* Holmgren (from Sumatra) is smaller than *A. paradentatus* and has a different shape of the mandibles.

TYPE LOCALITY: Budhapur (District Dadu), 6 soldiers (holotype, paratypes), workers, from underneath a brick, coll. S. I. Hussain, 4.9.1954.

Genus ***Angulitermes*** Sjostedt

KEY TO THE SPECIES

SOLDIERS

Frontal projection with broadly curved tip and with a small notch in the lower half; postmentum proportionately wider ... ... *A. dehraensis* (Gardner)

Frontal projection narrowly curved apically, with a depression in the middle; postmentum proportionately narrower ... ... *A. hussaini* n. sp.

28. ***Angulitermes dehraensis*** (Gardner)

Mirotermes dehraensis Gardner, 1944, pp. 108-110 (imago, soldier, worker).
Termes dehraensis Snyder, 1949, p. 179 (synonymy).

SOLDIER (Fig. 43): Head and anterior half of labrum brownish yellow; mandibles reddish brown; antennae slightly darker than the head; posterior part of labrum hyaline; pronotum slightly lighter than the head; rest of the body pale. Head with a few scattered bristles and short hairs; frontal projection with a few curved hairs on the anterior margin; tip of labrum with short hairs; pronotum scantily hairy. Head subquadrate, sides somewhat sinuate, widest a little anterior to the middle. The frontal projection with broadly curved tip, anterior side with a shallow notch in the ventral third, the margin above the notch slightly convex, and below the notch rounded. Projection at the side

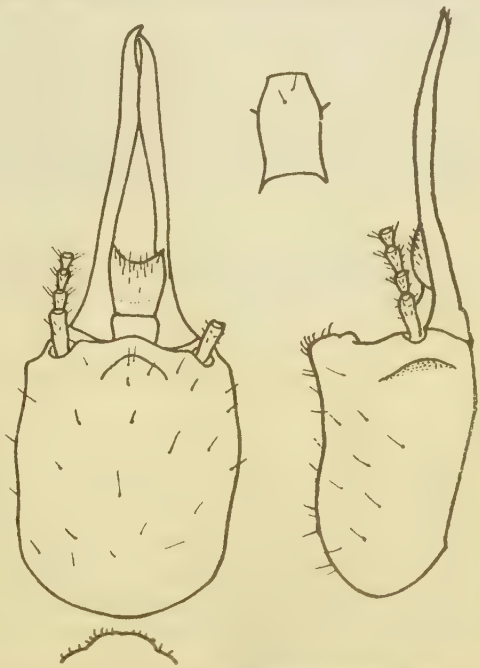


Fig. 43. *Angulitermes dehraensis* (Gardner), soldier Dorsal view of head and anterior half of pronotum; ventral view of postmentum; and side view of head.

of the head near the base of mandible prominent, broadly curved. Postmentum proportionately shorter, widest in the anterior half. Antenna with 14 articles, the second slightly shorter than the third, the fourth shortest. Labrum concave anteriorly, widest in the anterior half, sides converging posteriorly. Mandibles long, slender, snapping type, bow-shaped in side view, tip hooked, blade widest just below the tip. Pronotum strongly saddle-shaped, anterior lobe considerably raised.

TABLE 43

Measurements (in mm.) of the soldier of *Angulitermes dehraensis* (Gardner)

	No.	Range	Mean
Length of head with mandibles	4	2.54	2.54
Length of head to side base of mandibles	5	1.19-1.25	1.20
Width of head	8	0.92-0.94	0.94
Length of postmentum	8	0.42-0.46	0.43
Width of postmentum	8	0.25-0.33	0.29
Length of pronotum	6	0.18-0.21	0.20
Width of pronotum	6	0.46-0.50	0.48

REMARKS : This termite was identified by Dr Alfred E. Emerson. He informs the author that "*Mirotermes*" *obtusus* Holmgren, K. & N. (from Hospet, Bellary District, India) also belongs to the genus *Angulitermes*. It is the first record of the genus outside the Ethiopian region.

DISTRIBUTION : Lyallpur, 8 soldiers, workers, ex woodwork of a building, coll. N. A. Bashir, 28.8.1954. Sakesar (District Sargodha), two soldiers, coll. M. Ahmad, April, 1955.

29. *Angulitermes hussaini* n. sp.

SOLDIER (Fig 44) : Head yellowish brown ; mandibles light reddish brown ; anterior part of labrum brownish yellow, posterior part hyaline ; antennae light brown ; pronotum slightly lighter than the head ; rest of the body pale. Head sparsely hairy ; frontal projection with a few curved hairs ; labrum with a few short hairs ; pronotum sparsely hairy. Head subquadrate, widest in the anterior half, sides depressed a little below the middle. The frontal projection with narrowly rounded tip, the anterior side depressed in the middle, the margins above and below the depression straight. Projection at the side of the head at the base of the mandible not prominent, only slightly convex. Postmentum proportionately longer, widest in the outer half. Antenna with 14 articles,

the second shorter than the third, the fourth shortest. Labrum concave anteriorly, sides converging posteriorly, widest in the anterior half. Mandibles long, slender, snapping type, bow-shaped in side view, tip hooked, blade widest a little posterior to the tip. Pronotum strongly saddle-shaped, anterior lobe considerably raised, not emarginate.

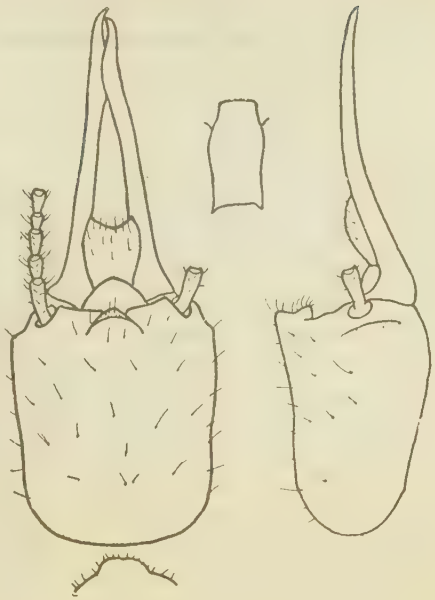


Fig. 44. *Angulitermes hussaini* n. sp., soldier: Dorsal view of head and anterior half of pronotum; ventral view of postmentum and side view of head.

TABLE 44

Measurement (in mm.) of the soldier of *Angulitermes hussaini* n. sp.

	No.	Range	Mean
Length of head with mandibles	3	1.92-2.00	1.97
Length of head to side base of mandibles	3	0.87-1.00	0.90
Width of head	3	0.81	0.81
Length of postmentum	3	0.44	0.44
Width of postmentum	3	0.25-0.27	0.26
Length of pronotum	3	0.29	0.29
Width of pronotum	3	0.46	0.46

COMPARISONS: Can be distinguished from *Angulitermes dehraensis* by its more pointed tip of frontal projection, less prominent projection at the side of the head near the base of the mandible, and proportionately narrower postmentum.

TYPE LOCALITY: Larkana, 3 soldiers (holotype, paratypes) collected along with soldiers and workers of *Microtermes* from a mound on canal bank on 28.7.1954 by S. Ishfaq Hussain in whose honour it is named.

Genus *Capritermes* Wasmann

30. *Capritermes punjabensis* Holmgren, K. & N.

Capritermes punjabensis Holmgren, K. & N., 1917, p. 170 (dealate). Snyder, 1949, p. 196.

IMAGO (Fig. 45) : Head brown ; mandibles yellowish brown, teeth dark reddish brown ; antennae brown ; labrum and postclypeus light brown ; pronotum a shade lighter than the head ; wings smoky brown. Head and pronotum densely hairy ; postclypeus moderately hairy ; labrum with a few bristles at the tip and on lateral sides. Head round. Fontanelle small, somewhat oval. Eye of medium size, round, slightly bulging, separated from the lower margin of the head by slightly less than half of its diameter. Ocellus large, oval, posterior end somewhat pointed, separated from the eye by half of its long diameter. Antenna with 15 articles, the second nearly twice as long as the third ; the fourth and third subequal. Postclypeus nearly half as long as wide. The left mandible with two marginal teeth, posterior cutting edge of the first marginal tooth sigmoid, second marginal tooth pointed. The right mandible with two marginal teeth, posterior cutting edge of the second marginal tooth concave. Pronotum subcordate, with a somewhat T-shaped median marking, and an ocellus-like marking on each lateral corner and a similar marking a little above the emargination of the posterior margin, anterior margin almost straight, posterior margin deeply emarginate.

Fig. 45. *Capritermes punjabensis* Holmgren, K. & N., imago : Dorsal view of head and pronotum ; side view of head ; and mandibles.

TABLE 45

Measurements (in mm.) of the imago of *Capritermes punjabensis* Holmgren, K. & N.

	No.	Range	Mean
Length of head to tip of labrum	10	0.91-1.09	0.98
Length of head to side base of mandibles	10	0.70-0.77	0.72

	No.	Range	Mean
Width of head	10	0.90-0.95	0.91
Large diameter of eye	10	0.19-0.21	0.20
Short diameter of eye	10	0.18-0.19	0.19
Eye from lower margin of head	10	0.09	0.09
Length of ocellus	10	0.09-0.12	0.10
Width of ocellus	10	0.07-0.09	0.07
Ocellus from eye	10	0.07-0.09	0.07
Length of pronotum	10	0.50-0.54	0.51
Width of pronotum	10	0.81-0.86	0.82

DISTRIBUTION : Lahore, 2 imagoes, at light, coll. M. Ahmad, 26.8.1953. Kohat, imagoes, at light, coll. Fazle Majid Khan, 18.7.1954.

BIBLIOGRAPHY

Ahmad, M., 1950. The phylogeny of termite genera based on imago-worker mandibles. Bull. Amer. Mus. Nat. Hist., **95** : 37-86.

Bugnion, E. & Popoff, N., 1910. Le termite a latex de Ceylan (*Coptotermes travians* Haviland). Mem. Soc. Zool. France, **23** : 107-123.

Chaudhry, G.U., 1954. A useful termite. Pak. J. Forestry, **4** : 31-32.

————, 1955. Notes on a collection of termites from Pakistan. *Ibid.*, **5** : 40-43.

Desneux, J., 1904. A new termite from India. J. Bombay Nat. Hist. Soc., **15** : 445-446.

————, 1906. Varietes termitologiques. Ann. Soc. Ent. Belg., **49** : 336-360.

Emerson, A.E., 1933. A revision of the genera of fossil and recent Termopsinae. (Isoptera). Calif. Univ. Publ. Ent., **6** : 165-196.

Gardner, J.C.M., 1944. New termites from India and Ceylon. Indian J. Ent., **6** : 103-110.

Hagen, H.A., 1858. Monographie der Termiten. Part 2. Linn. Ent., **12** : 1-342.

Holmgren, N., 1911. Termitenstudien II. Systematik der Termiten. Die Familien Mastotermitidae, Protermitidae und Mesotermitidae. K. Svenska Vetensk. Akad. Handl., **46** (6) : 1-88.

————, 1912. Termitenstudien III. Systematik der Termiten. Die Familie Metatermitidae. Ibid., **48** (4) : 1-166

————, 1913a. On some termites collected by Mr. Green in Ceylon. Spol. Zeyl., **8** : 277-284.

————, 1913b. Termitenstudien IV. Versuch einer systematischen

Monographie der Termiten der orientalischen Region. K. Svenska Vetensk. Akad. Handl., **50** (2) : 1-276.

————, 1913-14. Wissenschaftlichen Ergebnisse einer Forschungsreise nach Ostindien, ausgefuhrt in Austrage der Kgl. Preuss. Akademie der Wissenschaften zu Berlin von H.V. Buttel-Reepen III. Termiten aus Sumatra, Java, Malacca und Ceylon. Gesammelt von Herrn Prof. Dr. v. Buttel-Reepen in den Jahren 1911-1912. Zool. Jahrb. Abt. Syst., **36** : 229-290.

Holmgren, K. & N., 1917. Report on a collection of termites from India. Mem. Dept. Agric., India, **5** : 138-171.

Khan, M.A. & Ahmad, M., 1954. Termites of Lahore. Proc. 6th Pak. Sci. Conf., p. 140. (Abstract).

Radcliffe, E., 1904 (*Termopsis Radcliffei.*) Indian Forester Magazine, June, p. 412.

Rambur, J.P., 1842. Histoire naturelle des insectes. Nevropteres. Paris.

Silvestri, F., 1923. The termites of Barkuda Island. The fauna of an island in Chilka Lake. Rec. Indian Mus., **25** : 221-232.

Snyder, T.E., 1933a. Two new termites from India. Proc. Biol. Soc. Washington, **46** : 91-93.

————, 1933b. New termites from India. Proc. U.S. Nat. Mus., **82** : 1-15.

————, 1949. Catalog of the termites (Isoptera) of the World. Smiths. Misc. Coll., **112** : 1-490.

Wasmann, E., 1902. Termiten, Termitophilen und Myrmekophilen. Gesammelt auf Ceylon von Dr. W. Horn. Zool. Jahrb. Abt. Syst., **17** : 99-164.

A new Species of *Peniophora* from West Pakistan

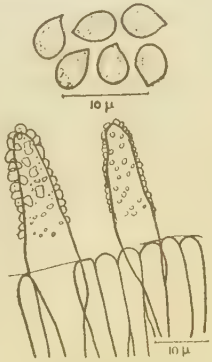
SULTAN AHMAD

Botany Department, Government College, Lahore.

Peniophora sedimenticola n. sp.

Fruit body more or less circular in outline, sometimes lining depressions or holes in the soil, resupinate, adnate, white or pale cinnamon pink, margin fibrillose ; context white, 450-500 μ thick ; basidia clavate, 15-24 x 4-4.5 μ, 4-sterigmate, sterigma 2-3 μ long ; spore print white, spores subglobose, shortly apiculate at the base, 1-guttulate, hyaline, 1-celled, 4.8-5.5 x 3.5-4.5 μ ; cystidia cylindric, apex pointed, base sub-ventricose, apical part thickly incrusted with crystals of calcium oxalate, scattered throughout the sub-hymenial tissue, 40-60 x 14-25 μ, those in the hymenial region projecting 30-35 μ above the surface.

On silt deposited on the sides of water courses, Ladhar (Sheikhupura), 17. 9. 47, no. 2176, type.



P. sedimenticola. Cystidia and spores.

Receptaculum plus minus rotundus, resupinatus, adnatus albus vel cinnamon ruber, marginaliter fibrillosum ; contextus albus, 450-500 μ crassus ; basidia clavata 4-sterigmata ; 15-24 x 4-4.5 μ ; sporae subglobosae, ad basem breviter apiculata, uno guttulata, hyalina ; unseptata, 4.8-5.5 x 3.5-4.5 ; cystidiis cylindraceis, apicibus acutis, basibus sub-ventricosis, pars apicalis incrustis ; dispersae in textura subhymenialis, 40-60 x 14-25 μ ; habitantes partibus hymenialis eiciunter in altitudineum 30-40 μ.

Hab. in limo deposito laterale rivorum.

BIOLOGICAL SOCIETY OF PAKISTAN

Constitution

NAME AND PURPOSE

1. The Society shall be called the Biological Society of Pakistan.
2. The headquarters of the Society shall be located at Lahore.
3. The object of the Society shall be the promotion of the cause of Biology in Pakistan.
4. The Society shall try to realize this object by
   (*a*) the publication of a Journal ;
   (*b*) holding meetings to discuss biological problems ; and
   (*c*) creating facilities for original research in Biology.
5. All persons interested in Biology can become members on the payment of the admission fee and the annual subscription.

PRIVILEGES OF MEMBERS

6. All members of the Society shall receive a copy of the Journal of the Society free.
7. An ordinary member of five years' standing, who has contributed original and meritorious papers to scientific journals of good repute, may be elected a Fellow upon a unanimous recommendation of the Executive Council. The numbers of such Fellows shall not exceed ten percent of the total membership of the Society.

SUBSCRIPTION

8. The annual subscription shall be payable to the Treasurer in advance of the year for which membership is sought.
9. The annual subscription for membership shall be Rs. 12/-, and fee for admission Rs. 5/-.
10. If the subscription remains unpaid for three months after January 1st., the name of such a member shall be removed from the membership of the Society.
11. If re-election is sought by a person who has been ejected for non-payment of subscription, he shall have to pay a fresh admission fee.

MANAGEMENT

12. The management of the Society shall rest with the Executive Council and the Editorial Board.

13. All affairs of the Society, except those concerning the publication and distribution of the Journal, shall be run by the Executive Council.

14. The publication and distribution of the Journal shall rest in the hands of the Editorial Board.

EXECUTIVE COUNCIL

15. The Executive Council shall consist of (*a*) President, (*b*) Secretary, (*c*) Treasurer, (*d*) Editor, and (*e*) three elected Councillors. Quorum of the Executive Council shall consist of five members.

16. All office-bearers, except the Treasurer, shall serve for one year only, but they will not be debarred from seeking election for a second term of office. The Treasurer shall hold office for three years.

17. The Treasurer shall submit, at the end of the year, the audited balance-sheet for scrutiny by the Executive Council.

EDITORIAL BOARD

18. The appointment of the Editorial Board shall rest with the Executive Council.

19. The Editorial Board shall consist of

    (*a*) three members, each of whom shall be appointed for two years,

    (*b*) the Treasurer of the Society, who shall also be the Business Manager of the Journal, and

    (*c*) the Secretary of the Society.

20. The annual subscription of the Journal from non-members shall be Rs. 15/- or its equivalent in foreign currency.

ELECTION TO OFFICE

21. All elections to the offices shall take place at the annual meeting of the Society which shall normally be held during Christmas recess. Interim vacancies shall be filled up at the instance of the Executive Council.

AMENDMENT TO RULES

22. The above rules may be amended at any annual general meeting by a two-third majority of the members present and voting.

LIST OF MEMBERS, 1955

1. Abdussalam, M., Professor of Pathology, College of Animal Husbandry, Lahore.
2. Abu Bakr, Senior Lecturer in Zoology, Panjab University, Lahore.
3. Afzal, M., Extra Assistant Director of Agriculture, Campbellpur.
4. Ahmad, Iftikhar, Department of Botany, Government College, Lahore.
5. Ahmad, Jawwad, Lecturer in Botany, Government College, Dera Ghazi Khan.
6. Ahmad, Moinuddin, Professor of Botany, Government College, Hyderabad.
7. Ahmad, Mushtaq, Lecturer in Biology, Talim-ul-Islam College, Rabwa.
8. Ahmad, Muzaffer, Senior Lecturer in Zoology, Panjab University, Lahore.
9. Ahmad, Nazir, Professor of Zoology, Government College, Lahore.
10. Ahmad, Niaz, Lecturer in Botany, Government College, Jhang.
11. Ahmad, Rafiq, Demonstrator in Botany, Karachi University, Karachi.
12. Ahmad, Sheikh Sher, Senior Lecturer in Zoology, Government College, Lahore.
13. Ahmad, Sultan, Senior Lecturer in Botany, Government College, Lahore.
14. Ahmad, Syed Nazeer, Lecturer in Biology, M. A.-O. College, Lahore.
15. Ahsan, Mohammad, Department of Zoology, Panjab University, Lahore.
16. Akhtar, Mahmud Ahmad, Department of Botany, Government College, Lahore.
17. Akhtar, S.A., I.C.I. Research Scholar, College of Animal Husbandry, Lahore.
18. Akhtar, (Miss) Shamim, Department of Botany, Government College, Lahore.
19. Alamdar, (Miss) Nafees, Government College, Lahore.
20. Ali, Shaukat, Assistant Professor of Botany, Agricultural College and Research Institute, Lyallpur.
21. Amatul-Aziz, (Miss), Government College, Lahore.
22. Amin, Muhammad, Professor of Biology, College of Animal Husbandry, Lahore.
23. Ansari, M. Atiqur Rehman, Institute of Hygiene and Preventive Medicine, Lahore.

24. Anwar, Mohammad, Department of Botany, Government College, Lahore.
25. Arif, Abdul Ghani, Plant Pathologist, Agricultural College and Research Institute, Lyallpur.
26. 'Arslan, Mohammad, Department of Zoology, Government College, Lahore.
27. Asim, S. M., Kashana Azam, 434-E, Samanabad, Lahore.
28. Aslam, Mian Muhammad, Senior Lecturer in Botany, Government College, Lahore.
29. Awan, (Miss) Barkat, Lecturer in Botany, Government College for Women, Peshawar.
30. Azhar, Muhammad, 47 Poonch Road, Lahore.
31. Aziz, Abdul, Department of Zoology, Government College, Lahore.
32. Bano, (Miss) N. Akhtar, Government College, Lahore.
33. Bashir, Nasir Ahmad, Department of Zoology, Government College, Lahore.
34. Beg, Asghar Ali, Lecturer in Botany, Islamia College, Lahore.
35. Beg, Mirza Nisar Ali, Senior Lecturer in Zoology, Government College, Lyallpur.
36. Begam, (Miss) Manzoor, Department of Zoology, Government College, Lahore.
37. Begum, (Miss) Saeeda, Department of Zoology, Government College, Lahore.
38. Bell, K. E., Department of Botany, F. C. College, Lahore.
39. Bhatty, M. Arshad Khan, Lecturer in Biology, M. A.-O. College, Lahore.
40. Bukhari, Waiz Husain, Lecturer in Zoology, Government College, Lyallpur.
41. Butt, Ecram, Lecturer in Botany, F. C. College, Lahore.
42. Chaudhri, Asghar Ali, Instructor in Biology, Lawrence College, Ghora Gali.
43. Chaudhri, Ikram Ilahi, Department of Botany, Government College, Lahore.
44. Chaudhri, Monawar Ahmad, Lecturer in Biology, Islamia College, Gujranwala.
45. Chaudhry, Sultan Ali, Associate Professor of Entomology, Agricultural College and Research Institute, Lyallpur.
46. Faridi, M. A. F., Senior Lecturer in Botany, Peshawar University, Peshawar.
47. Ghani, M. A., Associate Professor of Entomology, Agricultural College and Research Institute, Lyallpur.
48. Gilani, S. Shamshad Haider, Department of Zoology, Panjab University, Lahore.
49. Hafeez, Mohammad, Lecturer in Biology, Zamindara College, Gujrat.
50. Hafeezullah, Lecturer in Botany, Emerson College, Multan.

51. Hafiz, A., Director of Research, Food and Agriculture Council, Pakistan Secretariat, Karachi.
52. Hameedullah, Reader in Forestry, Pakistan Forest College, Abbottabad.
53. Haq, Kh. Abdul, Assistant Professor of Entomology, Agricultural College and Research Institute, Lyallpur.
54. Haq, Niazul, Department of Botany, Government College, Lahore.
55. Hasan, Agha Ahmad, Department of Biology, Government College, Quetta.
56. Hasan, Ashraf, Demonstrator in Botany, Panjab University, Lahore.
57. Hashmi, Hamid Ali, Department of Zoology, Government College, Lahore.
58. Hashmi, Tahir Ahmad, Department of Zoology, Panjab University, Lahore.
59. Hashmi, Tajammal Husain, Lecturer in Zoology, F. C. College, Lahore.
60. Husain, Ishtiaq, Lecturer in Botany, Government College, Lyallpur.
61. Husain, Khalifa Amjad, Warden of Fisheries, Lahore.
62. Husain, Muhammad Afzal, Vice-Chancellor, Panjab University, Lahore.
63. Husain, Nazir, Assistant Conservator of Forests, Leiah West.
64. Hussain, Syed Ishfaq, Demonstrator in Zoology, Government College, Lahore.
65. Iqbal, Mirza Muhammad, Lecturer in Botany, Government College, Bannu.
66. Iqbal, Qazi Muhammad, Lecturer in Botany, Government College, Quetta.
67. Islam, A., Senior Lecturer in Zoology, Government College, Lahore.
68. Jaffery, Iqbal Husain, Department of Botany, Government College, Lahore.
69. Jaffri, Saeed-ul-Haq, Department of Botany, Government College, Lahore.
70. Kausar, A. G., Plant Protection Division, Karachi.
71. Khalil-ur-Rehman, Lecturer in Zoology, Government College, Abbottabad.
72. Khan, Abdul Hamid, Forest Botanist, Pakistan Forest College, Abbottabad.
73. Khan, Akhlaq Ahmad, Department of Botany, Government College, Lahore.
74. Khan, Daler, Demonstrator in Zoology, Government College, Lahore.
75. Khan, Fazle Majid, Lecturer in Biology, Government College, Montgomery.
76. Khan, Inayat Ali, Lecturer in Zoology, Islamia College, Lahore.

77. Khan, Muhammad Ashraf, Lecturer in Botany, Government College, Lyallpur.
78. Khan, Muhammad Aslam, Lecturer in Zoology, Dyal Singh College, Lahore.
79. Khan, Musahib-ud-Din, Professor of Botany, Agricultural College and Research Institute, Lyallpur.
80. Khan, Nazir Ahmad, Department of Botany, Government College, Lahore.
81. Khan, Rafique Ahmad, Department of Botany, Islamia College, Lahore.
82. Khan, Mohammad Ziauddin, Sub-Divisional Officer, Pind Dadan Khan.
83. Khan, Shams-ul-Islam, Professor of Botany, Agricultural College, Peshawar University, Peshawar.
84. Khan, Zahir-ud-Din, Department of Zoology, Government College, Lahore.
85. Khanzada, S. K., Assistant Conservator of Forests, Shorkot.
86. Khokhar, A. R., Lecturer in Biology, Government College, Mianwali.
87. Latif, Abdul, Office of the Director of Public Instruction, Lahore.
88. Latif, Abdul, Professor of Entomology, Agricultural College and Research Institute, Lyallpur.
89. Lodhi, Sher Ahmad, Reader in Botany, Panjab University, Lahore.
90. Madan, (Miss) Prem, Lecturer in Botany, Government College for Women, Lyallpur.
91. Mahju, Nazir Ahmad, Department of Biology, Dyal Singh College, Lahore.
92. Mahmud, Khalid, Lecturer in Zoology, S. E. College, Bahawalpur.
93. Malik, Mohammad Anwar, Department of Zoology, Government College, Lahore.
94. Malik, Saeed Ahmad, Agricultural Officer, Kalat Division, Mastung.
95. Mallick, Muhammad Ashraf, Demonstrator in Botany, Islamia College, Lahore.
96. Maqsood, M., Professor of Physiology, College of Animal Husbandry, Lahore.
97. Masrur, Anwar, Lecturer in Pharmacognosy, Panjab University, Lahore.
98. Mirza, Ahmad Saeed, Lecturer in Biology, Government College, Rawalpindi.
99. Mohajir, A. R., Senior Lecturer in Botany, Karachi University, Karachi.
100. Mohyud Din, Agha Ikram, Department of Zoology, Government College, Lahore.
101. Muzaffer, Raja Muhammad, Lecturer in Zoology, M. A.-O. College, Lahore.
102. Naik, Ihsan Ullah, Department of Zoology, Government College, Lahore.

103. Naqvi, S. Imtiaz Akbar, Department of Zoology, Government College, Lahore.
104. Nasir, Eugene, Lecturer in Botany, Gordon College, Rawalpindi.
105. Nasir-ud-Daula, Pir, c/o Mr Sher Ahmad, Department of Zoology, Government College, Lahore.
106. Nawaz, Mohsin, Research Assistant, Cereal Section, Agricultural College and Research Institute, Lyallpur.
107. Nawaz, Muhammad, c/o Ch. Muhammad Sadiq, Neka Pura, Sialkot City.
108. Nizamuddin, Mohammad, Demonstrator in Botany, Karachi University, Karachi.
109. Parween, (Miss) Zubedah, Department of Botany, Government College, Lahore.
110. Qayyum, A., Lecturer in Zoology, Government College, Kohat.
111. Quayyoom, M. A., Entomological Research Assistant, Entomological Section, Agricultural College and Research Institute, Lyallpur.
112. Quraishi, Ahmad Ali, Professor of Botany, Government College, Lahore.
113. Qureshi, Ahmadullah, Lecturer in Zoology, Islamia College, Lahore.
114. Qureshi, Ashfaq Hussain, Lecturer in Biology, Government College, Mardan.
115. Qureshi (Miss) Bilqis, Government College, Lahore.
116. Qureshi, (Miss) Dilara, Senior Lecturer in Botany, Lahore College for Women, Lahore.
117. Qureshi, Hasan Ali, Divisional Forest Officer, Murree Forest Division, Rawalpindi.
118. Qureshi, M. Ajmal, Department of Zoology, Panjab University, Lahore.
119. Rahim, A., Department of Botany, Government College, Lahore.
120. Ranjha, A. R., Director, Zoological Survey of Pakistan, Karachi.
121. Raza, S. Mohsin, Lecturer in Zoology, Government College, Lyallpur.
122. Rizvi, (Miss) Zia Zehra, Department of Botany, Government College, Lahore.
123. Saeed, Ahmad, A.P.F.C., Muzaffarabad Forest Division, Muzaffarabad, Azad Kashmir.
124. Saleem, M., Lecturer in Zoology, Government College, Lahore.
125. Sarwar, S., Senior Lecturer in Zoology, Government College, Lahore.
126. Sattar, A., Assistant Director of Agriculture, West Pakistan, Lahore.
127. Shafiq, Shaikh Muhammad, 10 Circular Road, Lahore.
128. Shaikh, Basir Ali, Deputy Registrar (Examinations), Panjab University, Lahore.
129. Sharif, (Mrs) Kulsoom, 40 Hassar Road, Sialkot City.
130. Sheikh, Abdul Hamid, Senior Lecturer in Botany, Panjab University, Lahore.
131. Sheikh, Mahmood Iqbal, Divisional Forest office, Bhakkar.

132. Sheikh, Muhammad Arshad, Demonstrator in Botany, Panjab University, Lahore.

133. Siddiqi, Mohammad Ashfaq, Department of Zoology, Government College, Lahore.

134. Siddiqi, Muhammad Nasim, Department of Zoology, Government College, Lahore.

135. Syed, Rehman Anwar, Lecturer in Zoology, Gordon College, Rawalpindi.

136. Umar, Sheikh Muhammad, Vegetable Botanist, Agricultural College and Research Institute, Lyallpur.

137. Waheed, (Mrs) L. A., Lecturer in Botany, Lahore College for Women, Lahore.

138. Yaseen, Majid, Lecturer in Zoology, Islamia College, Lahore.

139. Yunas, Muhammad, Department of Entomology, Agricultural College and Research Institute, Lyallpur.

140. Zafar Aalam, Ch., Principal, Agricultural College and Research Institute, Lyallpur.

141. Zaidi, (Miss) Sughra Bano, Department of Botany, Government College, Lahore.

142 Zain-ul-Abidin, Lecturer in Botany, Panjab University, Lahore.

EXCHANGE LIST

The following Institutions have offered to exchange their publications with the BIOLOGIA. Offers received after the 20th December, 1955 could not be included in this list.

1. Botanisk Centralbibliotek, Koebenhavn, Danmark.
2. National Research Council of Egypt, Cairo, Egypt.
3. Senkenbergische Naturforschende Gesellschaft, Natur-Museum und Forschung-Institut, Frankfurt, Germany.
4. Academy of Zoology, Agra, India.
5. Forest Research Institute & Colleges, Deh-a Dun, India.
6. Bibliotheca-Bogoriensis, Bogor, Indonesia.
7. Bibliotheek Nederlandse Dierkundige Vereniging, Den Helder, The Netherlands.
8. Auckland Institute & Museum, Auckland, New Zealand.
9. Institute of Science & Technology, Manila, Philippines.
10. Royal Agricultural College of Sweden, Uppsala, Sweden.
11. Cambridge Philosophical Society, Cambridge, U. K.
12. Department of Botany, Birkbeck College, London, U.K.
13. Department of Zoology & Applied Entomology, Imperial College of Science & Technology, London, U. K.
14. University of Michigan, Ann Arbor, Mich., U. S. A.
15. University of California, Berkeley, Calif., U. S. A.
16. Museum of Comparative Zoology, Harvard University, Cambridge, Mass., U. S. A.
17. Arnold Arboretum, Cambridge, Mass., U. S. A.
18. University of North Carolina, Chapel Hill, North Carolina, U. S. A.
19. Lloyd Library & Museum, Cincinnati, Ohio, U. S. A.
20. Albert R. Mann Library, Cornell University, Ithaca, N. Y., U. S. A.
21. American Museum Natural History, New York, N.Y., U.S.A.
22. Stanford University, Stanford, Calif., U. S. A.
23. University of Illinois, Urbana, Ill., U. S. A.
24. Library of the Congress, Washington, D.C., U. S. A.
25. Marine Biological Laboratory, Woods Hole, Mass., U. S. A.

INDEX

New genera and species are indicated in bold type.

Acanthopterygii, scales of, 94
Ahmad, M., 25,202
see also Khan, M. A. & Ahmad, M.
Ahmad, S., 1,140,197,265
Akhtar, S. A., 31
Aleuria, 4
aurantia, 5
murreeana, 5
Aleurina, 5
pakistanica, 5
Aminul Haque, A. K. M., see Haque, A. K. M. A.
Amitermes, 254
belli, 254
paradentatus, 257
Anabas, scales of, 98
A. scandens, scales of, 98
Anacanthotermes macrocephalus, 210
Angulitermes, 259
dehraensis, 259
hussaini, 260
Ansari, M. A. R., 40
Aplastomorpha calandrae, ecological studies on, 115
Archotermopsis wroughtoni, 208
new flagellates from, 34
Ascobolus, 6
glaber, 7
immersus, 6
magnificus, 7
stercorarius, 7
Ascodesmis, 4
microscopica, 4
Ascophanus, 9
carneus, 9
granulatus, 10
ochraceous, 10
Azmatullah, see Hafiz, et al.
Barbus, scales of, 90
B. putitora, scales of, 90
B. chrysopterus, scales of, 91
B. sarana, scales of, 91
Butea monosperma, new species of *Meliola* on, 112
Capritermes punjabensis, 262
Carassius, scales of, 92
C. auratus, scales of, 92
Catla, scales of, 90
C. catla, scales of, 90
Chara, 74
brachypus, 80
braunii, 76
canescens, 77
contraria, 78
corallina, 75
deliculata, 79
fragilis, 80
vulgaris, 78
wallichii, 75
Characæ, 70
Charales of West Pakistan, 70
Cirrhina, scales of, 88
C. mrigala, scales of, 89
C. reba, scales of, 89
Colisa, scales of, 98
C. fasciata, scales of, 98
Coptotermes heimi, 213
Cyprinidæ, scales of, 85
Deuteromycetes from West Pakistan, 197
Dichomera,
gymnosporia, 197
macrospora, 197
Discomycetes, operculate, 1
Dispharynx alata 31
Eremotermes, 249
maliki, 253
neoparadoxalis, 252
paradoxalis, 249
Faridi, M. A. F., 70
Flagellates, new genera of, 34
Genus *Retortamonas*, 40
Geopyxis, 18
bronca, 19
cupularis, 19
Ghani, M. A. & Sweetman, H. L., 115
Gollaniella pusilla, studies on, 199
Granary weevil parasite, ecological studies on, 115
Hafiz, A., Azmatullah & Kafi, A., 112

Haque, A. K. M. A., 82
Helvella, 22
crispa, 23
elastica, 23
ephippium, 23
mitra, 22
Helvellaceæ, 20
Hendersonia astericola, 197
Heterotermes indicola, 215
Hodotermitidae, 207
Hornbill, new spirurid from, 31
Humaria, 14
ahmadii, 14
albospadicea, 16
gregaria, 15
hemisphærica, 15
pulcherrima, 15
scutellata, 14
Humarina, 10
gerardii, 12
luteola, 12
plumbeoatra, 12
semi-immersa 11
tetraspora, 11
umbrina, 12
zizyphi, 11
Hypermastigote flagellates, new genera of, 34
Imago of *Kalotermes beesoni*, 28
Islam, A., 141
Kafi, A.,
see Hafiz, et al.
Kalotermes beesoni, 204
imago of, 28
Kalotermitidae, 204
Khan, M.A., 199
Khan, M.A. & Ahmad, M., 28
Labeo, scales of, 85
L. calbasu, scales of, 86
L. gonius, scales of, 88
L. rohita, scales of, 85
Lamprospora, 4
trachycarpa, 4
Lasiobolus, 13
equinus, 14
Leptothyrium gleditschiae, 198
Lophomonadidae, 37
Meliola buteae, 112
Microcerotermes, 238
baluchistanicus, 243
championi, 245
heimi, 241
longignathus, 248
sakesarensis, 247
tenuignathus, 239
Microtermes, 229
mycophagus, 234
obesi, 231
pakistanicus, 25
sindensis, 236
unicolor, 229
Morchella, 20
conica, 21
crassipes, 21
deliciosa, 21
esculenta, 21
Neotermes pishinensis, 206
Nitella, 71
hyalina, 72
mucronata, 71
Notopteridae, scales of, 92
Notopterus, scales of, 92
N. chitala, scales of, 92
N. notopterus, scales of, 92
Odontotermes, 219
almorensis, 225
bangalorensis, 224
dehraduni, 226
gurdaspurensis, 222
obesus, 220
parvidens, 227
Ophicephalidae, scales of, 94
Ophicephalus, scales of, 94
O. gachua, scales of, 95
O. marulius, scales of, 94
O. punctatus, scales of, 95
O. striatus, scales of, 95
Osphronemidae, scales of, 98
Otidea, 16
leporina, 16
Parajoenopsis, 37
cephalotricha, 37
Paxina, 17
acetabulum, 18
hispida, 18
sulcata, 18
Peniophora sedimenticola, 265
Peziza, 19
badia, 19
repanda, 19
Pezizaceae, 3
Pezizales, 2
Physostomi, scales of, 85
Plectania, 17
coccinea, 17
occidentalis, 17

Prototrichonympha, 35
pristina, 35
Pyronema, 8
confluens, 8
Retortamonas, 40
agilis, 48
alexeiffi, 48
belostomae, 49
blattae, 49
bradypi, 50
caudacus, 52
caviae, 53
cuniculi, 53
dobelli, 54
gryllotalpae, 55
intestinalis, 56
mitrulae, 58
ovis, 58
phyllophagae, 59
ruminatum, 59
sinensis, 60
termitis, 62
testudae, 62
wenyoni, 64
Retortamonas, hosts of, 66
Rhinotermitidae, 212
Rhyparobius, 12
crustaceus, 13
Saccobolus, 7
depauperatus, 8
kerverni, 8
Saleem, M., 34
Scales, morphology of, 82
Scales of ——
Acanthopterygii, 94
Anabas scandens, 98
Barbus chrysopterus, 91
B. putitora, 90
B. sarana, 91
Carassius auratus, 92
Catla catla, 90
Cirrhina mrigala, 89
C. reba, 89
Colisa fasciata, 98
Cyprinidae, 85
Labeo calbasu, 86
L. gonius, 88
L. rohita, 85
Notopteridae, 92
Notopterus chitala, 92
N. notopterus, 92
Ophicephalidae, 94
Ophicephalus gachua, 95
O. marulius, 94
O. punctatus, 95
O. striatus, 95
Osphronemidae, 98
Physostomi, 85
Sciaena sp., 99
Sciaenidae, 99.
Sciaena sp., scales of, 99
Sciaenidae, scales of, 99
Septoria alhagiae, 198
Sepultaria, 13
arenicola, 13
Skull of *Uromastix hardwickii*, 141
Spirurid, a new, 31
Sweetman, H. L.,
see Ghani, M. A. & Sweetman, H. L.
Teleost scales, morphology of, 82
Termites of West Pakistan, 202
Termitidae, 218
Thecaphora atterima, 140
Tolypella, 72
glomerata, 73
prolifera, 73
Trichonymphidae, 35
Uromastix hardwickii, skull of, 141
Vermicularia arthraxonis, 198
Verpa, 22
bohemica, 22

SUGGESTIONS TO CONTRIBUTORS

Papers for publication in the *Biologia* should be typed in double spacing. They should include a short abstract and conclude with a summary of the contents. Tables (except very small ones), figures, and legends should be on separate sheets of paper and their approximate position marked in the text. Footnotes and tables should be avoided as far as possible. Nothing in the text, except scientific names, should be underlined.

References should be cited in the text by giving the author's name followed by the year of publication in brackets. At the end of the paper they should be listed in the alphabetical order of the names of the authors in the following style:

Ahmad, M., 1950. The phylogeny of termite genera based on imago-worker mandibles. Bull. Amer. Mus. Nat. Hist., 95: 37-86.

Illustrations should be made in line drawings with lettering in soft pencil. The authors may be required to bear the entire cost of coloured and half-tone blocks. The size of the plate after reduction should not exceed 7 x 4½ inches. The reduction desired should be indicated on the illustration. Photographs should be printed on white glossy paper.

A copy of the galley proof or, if possible, a page proof also will be sent to authors for correction. Authors should not insert new matter into proofs or correct faults in the style or arrangement of their papers at this stage.

Authors will receive 25 reprints free of charge; extra copies will be supplied at cost price.

All correspondence should be addressed to the Chief Editor, The *Biologia*, Biological Laboratories, Government College, Lahore.

CONTENTS

GHANI, M. A. & SWEETMAN, H. L., Ecological studies on the Granary Weevil Parasite, *Aplastomorpha calandrae* (Howard) ... 115

AHMAD, S., *Thecaphora atterima* Tulasne, a new record for West Pakistan 140

ISLAM, A., The skull of *Uromastix hardwickii* Gray ... 141

AHMAD, S., Six new Deuteromycetes from West Pakistan ... 197

KHAN, M. A., Studies on *Gollaniella pusilla* Stephani ... 199

AHMAD, M., Termites of West Pakistan 202

AHMAD, S., A new species of *Peniophora* from West Pakistan ... 265

Printed and published by Dr Sultan Ahmad at the Urdu Press,
88, McLeod Road, Lahore.